Historic, archived document

Do not assume content reflects current scientific knowledge, policies, or practices.

BULLETIN OF THE
U.S. DEPARTMENT OF AGRICULTURE
No. 215

Contribution from the Bureau of Chemistry, Carl L. Alsberg, Chief.
May 21, 1915.

(PROFESSIONAL PAPER.)

COMPOSITION OF CORN (MAIZE) MEAL MANUFACTURED BY DIFFERENT PROCESSES AND THE INFLUENCE OF COMPOSITION ON THE KEEPING QUALITIES.

By A. L. Winton,[1] W. C. Burnet, *Chemist in Charge, Savannah Food and Drug Inspection Laboratory*, and J. H. Bornmann, *Assistant Chemist*.

CONTENTS.

	Page.
Introduction	1
Consumption of corn meal	2
Manufacture of corn meal	3
Products of corn milling	5
Composition of the products of corn milling	6
Spoilage of meal	15
Relation of moisture content to keeping quality of degerminated bolted roller-ground meal	16
Comparative keeping quality of whole-kernel stone-ground meal and degerminated bolted roller-ground meal	22
Summary	30

INTRODUCTION.

The cause, detention, and prevention of the spoilage of Indian corn have been given special attention by the investigators in the Bureau of Plant Industry who have studied the subject from the chemical, biological, and toxicological standpoints. In view of the fact that an excess of moisture is conducive to spoilage as well as shrinkage, Brown and Duvel[2] have introduced a rapid method for the determination of this constituent which has come into extensive use in grain standardization laboratories as well as in elevators and mills. The percentages of moisture obtained by this process are important factors in determining the grade of market corn.

While moisture is doubtless the most important of the controllable factors causing deterioration, the determination of acidity has come to be recognized as the best chemical means of detecting actual spoilage, or at least a tendency in that direction. Italian and Austrian authorities have for some time placed dependence upon this determination in conjunction with certain qualitative tests which appear to have local significance. The Austrian chemist, Schindler,[1] described a method for acidity, and Black and Alsberg[2] in the United States have elaborated the details of the process in order to make it applicable for the use of those unskilled in laboratory manipulation. The process described by these authors has been further popularized by Besley and Baston,[3] and applied in their investigations on the soundness of corn. A certain amount of acid-reacting material, residing chiefly in the germ, is present in sound corn although no sour taste or smell is evident. During spoilage this acidity rapidly increases through the agency of molds or bacteria, or both, until the limit of tolerance is exceeded.

---

[1] Dr. Winton was formerly chemist in charge, Food Investigation Laboratory.

[2] Brown, Edgar, and Duvel, J. W. T. A Quick Method for the Determination of Moisture in Grain. U. S. Dept. Agr., Bureau of Plant Industry Bul. 99.

Note.—This bulletin is of interest to corn millers and dealers in corn and corn products and is suitable for distribution in all parts of the country.

Although the spoilage of corn, as such, has been the chief subject of investigation by the authors named, Black and Alsberg have also shown that the corn meal on the American market often contains an amount of acidity in excess of 30, the arbitrary limit adopted by the Austrian chemist Schindler. This figure, in chemical language, represents the number of cubic centimeters of normal alkali required to neutralize the acidity in the extract from 1,000 grams of the meal.

The main purpose of this paper is to show the general composition of American table meal milled by different processes, and especially the keeping qualities of the extreme types dried to different degrees and stored in different localities. Incidentally, the composition of grits and the by-products are considered.

The writers desire to express their appreciation for the assistance furnished by corn millers in various parts of the country who have permitted the inspection of their plants and furnished samples of corn and meal for analysis. Special thanks are due Mr. H. Bates, jr., president of the American Hominy Co., also Mr. F. C. Atkinson, chemist, and Mr. Charles Highstreet, general superintendent of that company, who threw open their mill at Terre Haute, Ind., for the experiments. Acknowledgment should also be made for the cooperation of Mr. W. J. McGee, former chief of the New Orleans Food and Drug Inspection Laboratory, and for the analytical work carried out by Mr. L. Patton, assistant chemist at the Savannah Food and Drug Inspection Laboratory.

CONSUMPTION OF CORN MEAL.

The consumption of corn meal is greatest in the Southern States of the Union, where in certain sections meal and grits are the principal cereal foods. Hon. E. J. Watson, commissioner of agriculture, commerce, and industries of the State of South Carolina, who has been particularly active in repressing the sale of spoiled meal in his State, is responsible for the statement that in South Carolina corn meal is not only the principal cereal product, but the most important of all articles of diet.[1] The same statement applies to many other regions in the South, particularly the rural districts, where wheat flour is of secondary importance and in some cases even a rarity. In many southern families, even in the cities, corn meal in some form or other is eaten three times a day, and in most families at least once a day.

---

[1] Schindler, Josef. Anleitung zur Beurteilung des Maises und seiner Mahlprodukte mit Rücksicht auf ihre Eignung als Nahrungsmittel. Innsbruck, 1909.

[2] Black, O. F., and Alsberg, C. L. The Determination of the Deterioration of Maize, with Incidental Reference to Pellagra, U. S. Dept. Agr., Bureau of Plant Industry Bul. 199.

[3] Besley, H. J., and Baston, G. H. Acidity as a Factor in Determining the Degree of Soundness of Corn, U. S. Dept. Agr. Bul. 102.

Among the common corn-meal dishes eaten in the South are hoecake, a mixture of corn meal and water with or without salt, cooked in a frying pan or griddle; corn bread or pone, made with the addition of baking powder or its equivalent and baked in the oven; griddle cakes, prepared from a thin batter with the addition of a leavening agent; egg or spoon bread, differing from ordinary corn bread in that eggs are used; and corn dumplings, usually cooked with either meat or vegetables. Corn meal is used in puddings, waffles, poultry dressing, meat and fish dishes. There is also a large consumption of mush made from hominy or grits and of lye hominy prepared from the whole grain after removal of the hull with caustic soda.

The corn and grits used in the South are prepared almost exclusively from white dent corn in both northern and southern mills. In the North, where corn products are consumed to a less degree, the preference is usually given to meal made from yellow corn, although the so-called hominy (grits) made from white corn is a common breakfast cereal. Hasty pudding (corn mush) and Johnny cake (corresponding to the hoecake of the South) have been made in New England households since colonial days. Indian pudding, a popular dessert prepared from corn meal, milk, and eggs, has long been regarded as one of the necessary adjuncts to the New England Thanksgiving dinner.

The dent varieties, both white and yellow, are generally used in the manufacture of meal and grits. A white variety known as "hominy corn," extensively grown in eastern Illinois and western Indiana, is preferred by many millers. In Rhode Island white flint corn has been milled for generations to produce a kind of meal much esteemed by the residents of that State, and in some other regions flint corn is milled to a limited extent.

MANUFACTURE OF CORN MEAL.

Although the consumption of meal is greatest in the South, the production of corn is greatest in the States of the Middle West forming the "corn belt." In the South the acreage is given up largely to the production of cotton, and the corn crop is not sufficient to supply the local demand. While the southern corn is used as far as it goes, and is usually preferred, the larger part of the meal is either ground by southern mills from western corn or is milled in the North, usually in or near the region where the corn is grown.

---

[1] Personal communication.

THE STONE PROCESS.

With few exceptions the southern mills grind the corn by stones. The chief difference between the process of the small country mill with a single "run of stone," which grinds the grist that the farmer brings in on his back, and that of the large mill, with several to 40 or 50 "run of stone," is in the perfection of the grain-cleaning and the bolting systems. In many of the mills native stones, notably the so-called Esopus stones from New York quarries, are preferred to French buhrs for the reason that they produce a soft, smooth meal, which is highly esteemed by southern cooks.

The term "water meal" has been applied indiscriminately to old-fashioned, stone-ground meal regardless of the fact that at the present time steam or even electricity is often the motive power. Naturally the nature of the milling machinery and not the power determines the character of the meal. Stone-ground meal is either milled from corn without bolting, and consequently does not differ in composition from the whole grain, except for the removal of a small amount of chaff by a simple fan device, or is bolted to remove the coarse bran and germ. It is stated that when unbolted meal is used the cook is accustomed to put it through a sifter, thus removing the greater part of the coarse, branny tissues, so that the final result attained is the same as if bolted meal had been used. Stone-ground meal, owing to the incomplete removal of the fatty matter of the germ, is characterized by its rich oily flavor, the taste for which when once acquired is not satisfied by degerminated meal in which the fat content is reduced to the minimum.

In the small stone mills no attempt is made to dry either the corn or the meal, although it is well known that the corn must be moderately dry in order to prevent gumming in the mill and to insure keeping for a reasonable length of time. The friction of grinding, especially when the stones are set for producing a very fine, soft meal, develops considerable heat, which serves to drive off much of the moisture. In certain of the large mills drying apparatus is used to some extent for removing the excess of moisture from either the corn or the meal. In many of the mills, however, dependence is placed on the heat developed during grinding as well as on the exposure of the hot meal to the air in open conveyors.

THE ROLLER PROCESS.

In northern mills rolls have largely replaced stones, the process being one of gradual reduction similar to that employed in wheat milling. Preliminary to grinding, the corn is put through the "degerminator," which loosens the germ, permitting its separation for the manufacture of corn oil. In some mills corrugated rolls take the place of the degerminator, but the product thus obtained may be contaminated with a considerable amount of oil. Reels and sifters similar to those employed in wheat milling are used in making the separation. In addition to the "degerminator" special forms of aspirators and driers, quite unknown in wheat milling, are peculiar to this process.

Corn, like wheat, is tempered by steam or water preliminary to the milling process, but it is considered necessary to dry the products, except in the summer months after the corn has become dry through long standing. This drying is usually effected in revolving horizontal cylinders containing steam pipes. The products and by-products are subjected to this drying process either before or after separation. The drying of the corn itself preliminary to milling is unusual.

PRODUCTS OF CORN MILLING.

Not only corn meal, but usually also grits and corn flour, as well as germ and feed, are obtained as the products and by-products of the roller process. In some mills two or more grades of meal are separated. These are designated either for table or brewers' use, or, according to the size of the particles, as coarse or fine. Grits and meal for brewers' use are the main products of some of the largest mills.

The grits are either used as such by the brewer or are rolled or "flaked" in order to facilitate malting. Special machines turn out continuous ribbons of rolled grits which are later broken up into thin flakes a fraction of an inch in size. A similar product serves for the manufacture of toasted corn flakes, a well-known, ready-for-use breakfast cereal.

Brewers' meal differs from table meal in that it contains more of the floury part of the kernel. The difference, however, is not marked and either can be used for both purposes. The brewing industry demands that both grits and meal contain not only the highest possible amount of starch, but also a low percentage of fat. A low percentage of moisture is also desired, not merely to increase thereby the percentage of starch but also to insure better keeping qualities.

Corn flour, the finely divided material separated by bolting, may be regarded as a by-product of the gradual reduction process. It serves as an ingredient of pancake flour and also as a filler or binder for sausage.

The germ, detached from the grain in the early stage of the process by the degerminator, is pressed for the manufacture of corn oil. Corn cake, the residue from the presses, is utilized for cattle food.

Corn bran corresponds to the bran obtained in the milling of wheat in the modern flour mill, and corn feed is the cattle food consisting usually of a mixture of bran and the finely divided offal analogous to red dog flour of the wheat mill. The ground corn cake is often an ingredient of corn feed.

COMPOSITION OF THE PRODUCTS OF CORN MILLING.

The analyses reported under this head are of samples obtained from corn mills in different sections of the country. With few exceptions the samples of meal were taken at the mills by the authors, so far as possible from the streams of corn going to the milling apparatus and of finished products going to the packers. They represent the products of forty-one mills located in thirty-two towns and seventeen States. The samples were shipped without delay to the Chicago Food and Drug Inspection Laboratory for analysis, the determinations being made as soon as the samples were received.

METHODS OF ANALYSIS.

The analyses were made by the methods of the Association of Official Agricultural Chemists, with the exception of the acidity, which was determined by the method employed by Schindler [1] and described in detail by Black and Alsberg.[2]

The determination of moisture by drying for five hours at the temperature of boiling water in a current of dry hydrogen was carried out in the apparatus devised by Winton.[3] The results obtained by means of this apparatus were about 1 per cent higher than those obtained by drying for the same length of time and at the same temperature in an open dish. The reason for this difference is not clear, but is probably, in part at least, physical. The fact that the difference was well marked in the case of degerminated meal containing less than 1 per cent of fat precludes the assumption that the cause lies in the prevention of oxidation by the hydrogen method.

Great annoyance and sometimes heated disputes have resulted from discrepancies in the results of a moisture determination by different methods and in different laboratories, particularly those of the buyer and seller. As the process used in these experiments has given concordant results in mill laboratories as well as in those of the department, it is believed that the extra labor and expense involved as compared with drying in an open dish will recommend it, at least for use in standardizing such shorter processes as the official or trade chemist may find convenient. In this connection attention is directed to the modification of the Brown and Duvel apparatus adapted for the determination of moisture in meal which has recently been devised by Cox.[4] It is hoped that this method will be of great value to the trade. So far there has not been opportunity to compare the results obtained by this apparatus with those by the gravimetric method employed in these investigations.

---

[1] Loc. cit. p. 37.

[2] Loc. cit. p. 10.

[3] Winton, A. L. Conn. Agr. Expt. Sta. Rept., 1889, p. 187; Leach, Albert E. Food Inspection and Analysis, p. 62.

[4] Cox, John H. A Special Flask for the Rapid Determination of Water in Flour and Meal. U. S. Dept. Agr. Bul. 56.

FULL SET OF PRODUCTS OF TWO ROLLER MILLS.

In Table 1 are given analyses of samples representing all the products and by-products obtained in two corn mills, one, grinding white corn, located in the Middle West, the other, grinding yellow corn, on the Pacific slope.

PROCESS OF MANUFACTURE.

A description of the process used in the white-corn mill, as furnished by the chemist, follows:

> Number three[1] white corn is carried from the elevator or bin through a magnetic separator to remove nails, etc., then through a screen to remove large pieces of cobs or other foreign matter and over a fine screen to remove sand and grit. It is then aspirated with a strong air current to remove impurities of a light, fluffy nature.
>
> The cleaned corn now goes through the tempering device and to the degerminator. In the latter machine the kernels are broken open, the germs are partly broken loose from the starchy portion of the grain, and the bran is partially removed. This broken corn is dried and allowed to flow through the hominy separator. In this machine the stock is led through a revolving sheet-iron cylinder, through the metal of which are numerous narrow slots. Within this cylinder are beaters revolving in the opposite direction from the cylinder. This removes some bran and most of the rotten grains, which latter are shattered into very fine particles as they pass through the degerminators.
>
> From this cylinder the stock passes through a sizing reel which removes all the material fine enough to pass a number seven screen (seven meshes to the linear inch). At the same time it is aspirated to remove dust and bran. The coarse portion from this machine, which is now quite well cleaned, is passed through the first, second, and third break rolls, being screened after each break, separating flour, meal, fine grits, coarse grits, and hominy.
>
> As the products attain the desired degree of fineness they are aspirated thoroughly before bagging.

In the yellow-corn mill both dent and flint corn, either separately or mixed, are milled, the process, as described by the head miller, being as follows:

> The corn first passes through a degerminator which removes the bran and germ. It is then thoroughly dried and allowed to remain in the bin long enough to cool to about its normal temperature. From thence it passes through a series of rolls, being gradually reduced to the proper fineness. The chaffy material is removed by suction, after which the meal is sterilized at a temperature of 218° F., the process requiring a little over three minutes. When the meal has cooled off slightly it is packed in sacks or other suitable containers.

ANALYSES OF THE PRODUCTS.

A study of the analyses in Table 1 shows that the percentages of fat and ash in the white corn grits and in the coarse yellow corn meal correspond very closely to the percentages of these constituents in patent wheat flour, showing that the gradual reduction process eliminates quite completely the bran and impurities. The percentages of fat and ash in both kinds of white corn meal and in the fine yellow corn meal are about the same as those present in clear wheat flour. The analogy ceases in the case of protein, as the corn products with low fat and ash contents contain relatively high amounts of protein, whereas the reverse is true of the different grades of wheat flour.

---

[1] This is the old No. 3 grade used by the trade prior to the adoption of the Government corn grades in July, 1914. Corn graded No. 4 on account of moisture is often used. No. 2 corn is found comparatively rarely and then only in summer and early fall.

TABLE 1.—*Composition of the products and by-products of corn milling.*

Product.	Analysis as received.							Analysis calculated to moisture-free basis.					
	Moisture.	Acidity.	Protein (N×6.25).	Fat.	Nitrogen-free extract.	Crude fiber.	Ash.	Acidity.	Protein. (N×6.25).	Fat.	Nitrogen-free extract.	Crude fiber.	Ash.
White corn, products, and by-products:	*P.ct.*		*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*		*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*
Corn	13.52	27.5	9.12	3.62	70.50	2.02	1.22	31.8	10.55	4.19	81.51	2.34	1.41
Grits, coarse	13.07	16.4	8.78	.48	76.78	.53	.36	18.9	10.10	.55	88.33	.61	.41
Grits, fine	12.12	16.6	8.66	.64	77.68	.48	.42	18.9	9.85	.73	88.39	.55	.48
Meal, cream	11.97	19.1	7.85	1.41	77.65	.56	.56	21.7	8.92	1.60	88.20	.64	.64
Meal, brewers'	11.95	18.1	8.00	1.23	77.59	.64	.59	20.6	9.08	1.40	88.12	.73	.67
Flour	11.19	22.1	6.78	2.87	77.61	.80	.75	24.9	7.63	3.23	87.40	.90	.84
Germ	6.64	59.3	16.62	23.79	40.30	6.04	6.61	63.5	17.80	25.48	43.17	6.47	7.08
Germ cake	2.14	68.6	20.22	7.26	54.39	7.90	8.09	70.1	20.66	7.42	55.58	8.07	8.27
Feed (including bran)	11.00	52.4	11.69	8.44	60.99	5.03	2.85	58.9	13.13	9.48	68.54	5.65	3.20
Bran	10.13	49.2	8.43	6.71	62.85	9.72	2.16	54.7	9.38	7.47	69.93	10.82	2.40
Yellow corn, products, and by-products:													
Corn	13.45	35.4	9.16	5.10	68.89	2.06	1.34	40.9	10.58	5.89	79.60	2.38	1.55
Meal, bolted, coarse	12.88	18.0	9.78	.90	75.60	.45	.39	20.7	11.23	1.03	86.77	.52	.45
Meal, bolted, fine	13.10	21.1	9.09	2.19	74.48	.53	.61	24.3	10.46	2.52	85.71	.61	.70
Germ	11.29	62.5	13.34	18.07	49.25	3.98	4.07	70.5	15.04	20.37	55.51	4.49	4.59
Bran	10.37	66.5	9.06	11.00	57.19	9.68	2.70	74.2	10.11	12.27	63.81	10.80	3.01

It should be especially noted that the acidity of both the grits and the meal is much less than that of the corn, the figures being well within the limit 30, notwithstanding the high amount in the corn which was characteristic of the crop of 1913.

Corn flour is not comparable with any of the commercial grades of wheat flour, although in respect to both process and composition it has some resemblance to break flour. The acidity, fat, and ash contents are higher in the flour than in the meal and grits, whereas the protein content is lower.

The germ is characterized by its high content of acidity, protein, fat, fiber, and ash, all of which constituents, except the fat, are obviously further increased in percentage amount by pressing. The high acidity at once shows the chief seat of the acid-reacting materials and the advantage of degermination.

The samples of bran, while containing about the same amount of protein as the corn, are characterized by their higher fat, fiber, and ash content. The feed is still richer in fat and ash as well as in protein. These results show the value of this offal for feeding, but the high acidity is significant proof of its unsuitability for human food.

WHOLE-KERNEL STONE-GROUND MEAL.

The samples without exception were from southern mills. Analyses of both the meal and the corn from which it was milled appear in Table 2. As the corn was ground without the removal of any constituent other than some of the thin, papery chaff or "bee wing," the meal when ground should not differ materially from the corn in composition, except for a possible change in moisture content. Whether or not the moisture is less or greater than in the corn depends on the dryness of the latter and on the climate. Ordinarily there is a loss in grinding.

TABLE 2.—*Composition of whole-kernel, stone-ground meal and of corn from which meal was milled.*

Product.	Analysis as received.							Analysis calculated to moisture-free basis.					
	Moisture.	Acidity.	Protein (N×6.25).	Fat.	Nitrogen-free extract.	Crude fiber.	Ash.	Acidity.	Protein (N×6.25).	Fat.	Nitrogen-free extract.	Crude fiber.	Ash.
White corn and meal:													
Mill No. 1, Alabama—	*P. ct.*		*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*		*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
Corn, Middle West	13.05	32.0	8.47	3.70	71.49	2.00	1.29	36.8	9.74	4.26	82.22	2.30	1.48
Meal, unbolted	13.28	32.2	8.38	3.59	71.34	2.12	1.29	37.2	9.66	4.14	82.26	2.45	1.49
Mill No. 2, Alabama—													
Corn, Tennessee	12.41	20.0	8.25	4.16	71.90	2.00	1.28	22.8	9.42	4.75	82.09	2.28	1.46
Meal, unbolted	12.30	34.1	8.00	4.27	72.00	2.05	1.38	38.9	9.12	4.87	82.10	2.33	1.58
Mill No. 3, Georgia—													
Corn, Indiana	13.28	25.2	8.19	3.75	71.52	2.07	1.19	29.0	9.44	4.32	82.49	2.38	1.37
Meal, unbolted	11.97	26.0	8.47	3.65	72.52	2.15	1.24	29.5	9.62	4.15	82.38	2.44	1.41
Mill No. 4, Georgia—													
Corn	13.99	25.4	8.81	3.78	70.19	1.95	1.28	29.5	10.24	4.40	81.61	2.26	1.49
Meal, unbolted	12.38	27.4	8.66	3.81	71.83	1.98	1.34	31.3	9.88	4.35	81.98	2.26	1.53
Mill No. 5, Georgia—													
Corn, Middle West	14.04	23.0	8.59	3.55	70.54	2.04	1.24	26.8	10.00	4.13	82.06	2.37	1.44
Meal, unbolted	12.51	28.0	8.31	3.75	71.97	2.19	1.27	32.0	9.50	4.29	82.25	2.51	1.45
Mill No. 6, South Carolina—													
Corn, South Carolina	11.73	18.0	7.90	4.45	72.69	2.05	1.18	20.4	8.95	5.04	82.35	2.32	1.34
Meal, unbolted	11.16	20.7	7.94	4.39	73.21	2.10	1.20	23.3	8.94	4.94	82.41	2.36	1.35
Mill No. 7, Tennessee—													
Corn, Tennessee	11.82	18.0	7.00	4.29	73.56	2.07	1.26	20.4	7.94	4.87	83.42	2.34	1.43
Meal, entire kernel	13.09	24.5	7.25	4.18	72.25	2.01	1.22	28.2	8.34	4.81	83.13	2.32	1.40
Mill No. 8, Mississippi—													
Corn, Mississippi	12.13	31.0	9.09	4.42	71.06	2.07	1.23	35.3	10.35	5.03	80.87	2.35	1.40
Meal, unbolted	13.18	37.2	8.47	4.25	70.60	2.17	1.33	42.9	9.75	4.90	81.32	2.50	1.53
Mill No. 9, Mississippi—													
Corn, Kentucky	12.54	30.0	9.22	4.24	70.73	1.91	1.36	34.3	10.54	4.85	80.87	2.19	1.55
Meal, unbolted	12.31	42.7	9.41	4.18	70.74	1.99	1.37	48.7	10.73	4.77	80.67	2.27	1.56
Mill No. 10, Mississippi—													
Corn, Mississippi	11.86	24.7	8.19	4.63	71.88	2.09	1.35	28.1	9.29	5.26	81.55	2.37	1.53
Meal, unbolted	11.58	25.1	7.97	4.49	73.09	1.55	1.32	28.4	9.01	5.08	82.66	1.76	1.49
Mill No. 11, Missouri—													
Corn, Middle West	15.83	21.3	8.78	3.67	68.65	1.84	1.23	25.3	10.44	4.36	81.56	2.18	1.46
Meal, straight	10.17	21.3	9.03	3.56	74.52	1.36	1.36	23.7	10.05	3.96	82.96	1.51	1.52
Meal: Maximum	13.28	42.7	9.41	4.49	74.52	2.19	1.38	48.7	10.73	5.08	83.13	2.51	1.58
Meal: Minimum	10.17	20.7	7.25	3.56	70.60	1.36	1.20	23.3	8.34	3.96	80.67	1.51	1.35
Meal: **Average**	**12.18**	**29.0**	**8.35**	**4.01**	**72.19**	**1.97**	**1.30**	**33.1**	**9.51**	**4.57**	**82.19**	**2.25**	**1.48**

The remarkable agreement in the percentages other than moisture and acidity is as would be expected, but the greater amount of acidity in the meal requires explanation. That the acidity of both corn and freshly ground meal would be the same is obvious, but the increase in the meal is much more rapid than in the corn. In cases where the acidity of the meal is in excess the cause is directly traceable to delay in delivery of the samples, which in some instances was a week or more. Experience shows that corn will not materially increase in acidity during that time.

The acidity given in Table 2 for the corn should in all cases be taken as that of the corresponding meal at the time of grinding.

The excessive amount of acidity in some of the samples of meal when analyzed merely illustrates the difficulty in keeping meal of this type, which fact is further brought out by the results of the later experiments. (See Tables 12 and 14.)

BOLTED UNDEGERMINATED MEAL.

Results obtained in the analysis of bolted, undegerminated meal, as well as of the corn from which it was milled, appear in Table 3. The mills in which the corn was ground are all located in the South except No. 18, which is in Iowa, and No. 35, which is in Rhode Island. In most of the mills grinding was done by stones; in Nos. 18, 36, 37, and 38, however, rolls were used. The corn ground in all the southern mills was white dent, in the Iowa mill it was yellow dent, and in the Rhode Island mill it was white flint.

TABLE 3.—*Composition of bolted, undegerminated corn meal and of corn from which meal was milled.*

Product.	Analysis as received.							Analysis calculated to moisture-free basis.					
	Moisture.	Acidity.	Protein (N×6.25).	Fat.	Nitrogen-free extract.	Crude fiber.	Ash.	Acidity.	Protein (N×6.25).	Fat.	Nitrogen-free extract.	Crude fiber.	Ash.
White corn and meal:													
Mill No. 1, Alabama—	*P. ct.*		*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*		*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
Corn, Middle West	13.05	32.0	8.47	3.70	71.49	2.00	1.29	36.8	9.74	4.26	82.22	2.30	1.48
Meal, bolted	14.94	33.8	7.75	2.92	72.53	.83	1.03	29.8	9.11	3.43	85.27	.98	1.21
Mill No. 4, Georgia—													
Corn	13.99	25.4	8.81	3.78	70.19	1.95	1.28	29.5	10.24	4.40	81.61	2.26	1.49
Meal, bolted	12.60	27.7	9.09	3.72	71.94	1.48	1.17	31.7	10.40	4.26	82.30	1.70	1.34
Mill No. 34, Georgia—													
Corn	12.79	23.5	8.93	4.30	70.62	2.06	1.30	26.9	10.24	4.93	80.98	2.36	1.49
Meal, bolted	11.32	26.2	9.22	4.35	72.12	1.64	1.35	29.6	10.39	4.90	81.34	1.85	1.52
Mill, No. 5, Georgia—													
Corn, Middle West	14.04	23.0	8.59	3.55	70.54	2.04	1.24	26.8	10.00	4.13	82.06	2.37	1.44
Meal, bolted	11.60	25.5	8.87	3.78	72.77	1.68	1.30	28.8	10.04	4.27	82.32	1.90	1.47
Mill No. 21, Missouri—													
Corn, Middle West	14.87	25.8	8.75	3.58	69.47	1.99	1.34	30.3	10.28	4.20	81.62	2.34	1.56
Meal, bolted	12.78	24.1	8.97	3.04	72.92	1.17	1.12	27.6	10.28	3.49	83.61	1.34	1.28
Mill No. 9, Mississippi—													
Corn, Kentucky	12.54	30.0	9.22	4.24	70.73	1.91	1.36	34.3	10.54	4.85	80.87	2.19	1.55
Meal, bolted	12.45	44.5	9.06	4.72	70.88	1.38	1.51	50.8	10.35	5.39	80.96	1.58	1.72
Mill No. 35, Rhode Island—													
Corn, R. I. flint	12.93	22.5	9.50	4.47	69.94	1.83	1.33	25.8	10.91	5.13	80.33	2.10	1.53
Meal, bolted	10.12	21.7	8.97	4.83	73.39	1.31	1.38	24.2	9.98	5.38	81.64	1.46	1.54

TABLE 3.—*Composition of bolted, undegerminated corn meal and of corn from which meal was milled*—Continued.

Product.	Analysis as received.							Analysis calculated to moisture-free basis.					
	Moisture.	Acidity.	Protein (N×6.25).	Fat.	Nitrogen-free extract.	Crude fiber.	Ash.	Acidity.	Protein (N×6.25).	Fat.	Nitrogen-free extract.	Crude fiber.	Ash.
White corn and meal—Continued.													
Mill No. 36, Tennessee—	*P. ct.*		*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*		*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
Corn, Middle West..	13.14	26.2	8.28	3.85	71.45	2.04	1.24	30.2	9.54	4.43	82.25	2.35	1.43
Meal, plain..........	13.72	46.0	8.78	4.83	69.33	1.73	1.61	53.3	10.17	5.59	80.37	2.01	1.86
Meal, bolted.........	14.25	45.5	9.03	5.14	68.31	1.62	1.65	53.1	10.53	6.00	79.66	1.89	1.92
Mill No. 37, Tennessee—													
Corn, uncleaned.....	12.60	24.7	8.34	3.73	72.06	2.00	1.27	28.3	9.55	4.27	82.44	2.29	1.45
Meal, cream.........	14.39	31.0	7.47	2.75	73.76	1.77	.86	36.2	8.72	3.22	86.15	.90	1.01
Mill No. 38, Tennessee—													
Corn, Tennessee.....	13.81	19.2	9.40	4.63	68.83	1.94	1.39	22.3	10.91	5.38	79.85	2.25	1.61
Meal, bolted.........	15.09	27.5	8.47	3.58	70.54	1.15	1.17	32.3	9.97	4.22	83.07	1.36	1.38
Mill No. 39, Tennessee—													
Corn, Tennessee.....	14.19	21.7	9.09	4.18	69.46	1.75	1.33	25.3	10.59	4.87	80.96	2.03	1.55
Meal, bolted.........	13.31	24.0	9.18	4.11	71.19	.86	1.35	27.7	10.59	4.74	82.13	.99	1.55
Meal, pearl..........	12.87	20.7	8.78	2.98	73.54	.83	1.00	23.8	10.07	3.42	84.41	.96	1.14
Mill No. 40, Virginia—													
Corn, Middle West..	14.69	27.7	8.72	3.55	69.67	2.14	1.23	32.5	10.23	4.16	81.66	2.51	1.44
Meal, bolted.........	12.51	28.5	8.84	3.90	71.66	1.77	1.32	32.6	10.11	4.45	81.90	2.03	1.51
Meal Maximum..	15.09	46.0	9.22	5.14	73.76	1.77	1.65	53.3	10.59	6.00	86.15	2.03	1.92
Meal Minimum...	10.12	20.7	7.47	2.75	68.31	.77	.86	23.8	8.72	3.22	79.66	.90	1.01
Meal **Average....**	**12.99**	**30.5**	**8.75**	**3.90**	**71.79**	**1.30**	**1.27**	**35.1**	**10.05**	**4.48**	**82.51**	**1.50**	**1.46**
Yellow corn and meal:													
Mill No. 18, Iowa—													
Corn, Middle West...	16.95	19.6	8.59	3.55	67.58	2.06	1.27	23.6	10.35	4.28	81.37	2.48	1.52
Meal, Porto Rico trade.............	16.82	24.3	7.16	1.95	72.79	.66	.62	29.2	8.61	2.35	87.52	.79	.73

The effect of bolting in all cases was a decrease in fiber, but further than this no general rule can be deduced, as conditions such as fineness of grinding and the size of the meshes of the bolts exert more influence than the mere fact of bolting. The markedly high acidity in the meal from mills 9 and 36 was doubtless due to the length of time elapsing between grinding and analysis, which for reasons already stated was from 9 to 12 days.

DEGERMINATED BOLTED ROLLER-GROUND MEAL.

The general name "cream meal" is applied to degerminated, bolted, roller-ground meal when made from white corn, but various terms are used for the corresponding product from yellow corn. Analyses of both white and yellow meal and of the corn from which the meal was milled will be found in Table 4. The samples were from mills located in the Northern States and in Tennessee. All the mills were equipped with rolls and modern machinery for cleaning the grain as well as for separating and drying the products. Most of the mills employed degerminators, while others depended on corrugated rolls for loosening the germ and bran from the endosperm.

TABLE 4.—*Composition of degerminated, bolted, roller-ground meal and of corn from which meal was milled.*

Product.	Analysis as received.							Analysis calculated to moisture-free basis.					
	Moisture.	Acidity.	Protein (N×6.25).	Fat.	Nitrogen-free extract.	Crude fiber.	Ash.	Acidity.	Protein. (N×6.25).	Fat.	Nitrogen-free extract.	Crude fiber.	Ash.
White corn and meal:													
Mill No. 12, Illinois—	*P. ct.*		*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*		*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
Corn, Middle West..	16.28	19.0	8.41	3.39	68.72	2.00	1.20	22.7	10.03	4.04	82.11	2.39	1.43
Meal, pearl..........	13.08	10.6	6.56	.99	78.40	.62	.35	12.2	7.54	1.14	90.21	.71	.40
Mill No. 13, Illinois—													
Corn, Middle West..	13.92	18.5	8.63	3.55	70.49	2.19	1.22	21.5	10.02	4.12	81.91	2.54	1.41
Meal, cream..........	16.17	13.2	6.63	.80	75.36	.67	.37	15.7	7.90	.94	89.93	.80	.43
Mill No. 14, Illinois—													
Corn, Middle West..	17.11	23.8	8.16	3.37	68.12	2.06	1.18	28.7	9.84	4.07	82.19	2.48	1.42
Meal, brewers'.......	14.58	15.6	5.81	1.15	77.35	.73	.38	18.2	6.80	1.35	90.55	.85	.45
Mill No. 15, Indiana—													
Corn, Middle West..	17.38	19.8	8.25	3.34	67.86	2.00	1.17	23.9	9.96	4.03	82.18	2.42	1.41
Meal, cream..........	14.44	11.9	6.16	1.28	77.06	.67	.39	13.9	7.18	1.49	90.09	.78	.46
Mill No. 16, Indiana—													
Corn, Middle West..	17.32	19.0	8.50	3.26	67.75	2.02	1.15	22.9	10.25	3.93	82.00	2.44	1.38
Meal, cream..........	13.85	13.5	7.50	.87	76.85	.58	.35	15.6	8.69	1.00	89.24	.67	.40
Mill No. 17, Iowa—													
Corn, Middle West..	16.24	22.5	8.81	3.17	68.54	2.02	1.22	26.9	10.52	3.79	81.82	2.41	1.46
Meal, cream..........	13.97	15.7	7.19	.75	77.07	.61	.41	18.2	8.36	.87	89.59	.71	.47
Mill No. 18, Iowa—													
Corn, Middle West..	16.09	27.8	8.50	3.77	68.45	1.98	1.21	33.1	10.13	4.49	81.58	2.36	1.44
Meal, pearl..........	18.28	20.8	7.00	1.22	72.41	.60	.49	25.5	8.57	1.50	88.60	.74	.59
Mill No. 19, Maryland—													
Corn, Chicago........	14.71	21.2	8.31	3.68	70.04	2.09	1.17	24.9	9.74	4.31	82.13	2.45	1.37
Meal, fancy cream...	13.78	23.0	6.28	1.43	77.35	.68	.48	26.7	7.29	1.66	89.70	.79	.56
Mill No. 20, Michigan—													
Corn, Middle West..	12.92	23.1	8.59	3.70	71.47	2.07	1.25	26.5	9.87	4.25	82.06	2.38	1.44
Meal.................	12.83	18.9	7.97	1.54	76.39	.64	.63	21.7	9.14	1.76	87.64	.74	.72
Mill No. 21, Missouri—													
Corn, Middle West..	14.87	25.8	8.75	3.58	69.47	1.99	1.34	30.3	10.28	4.20	81.62	2.34	1.56
Meal, cream..........	12.81	21.6	8.84	2.08	74.59	.87	.81	24.7	10.14	2.39	85.56	.99	.92
Mill No. 22, Missouri—													
Corn.................	15.19	24.2	8.81	3.54	69.20	1.92	1.34	28.4	10.39	4.17	81.59	2.27	1.58
Meal, cream..........	13.77	14.5	7.47	1.80	75.64	.69	.63	16.8	8.66	2.08	87.73	.80	.73
Mill No. 23, Missouri—													
Corn.................	16.19	23.3	8.00	3.52	69.10	1.96	1.23	27.8	9.54	4.20	82.45	2.34	1.47
Meal, cream..........	14.78	19.1	6.81	1.60	75.58	.70	.53	22.3	7.99	1.88	88.69	.82	.62
Mill No. 24, New York—													
Corn, Middle West..	13.25	21.1	8.81	3.77	70.88	2.06	1.23	24.4	10.16	4.35	81.70	2.37	1.42
Meal, cream..........	13.56	14.7	5.91	1.45	77.86	.72	.50	17.1	6.83	1.68	90.07	.84	.58
Mill No. 25, Pennsylvania—													
Corn, Middle West..	14.10	27.0	8.56	3.56	70.48	2.11	1.19	31.4	9.97	4.14	82.05	2.45	1.39
Meal, cream..........	14.08	20.2	6.65	1.75	76.12	.77	.63	23.6	7.75	2.04	88.58	.90	.73
Meal, Southern trade.	13.59	22.3	6.66	2.04	76.25	.80	.66	25.8	7.70	2.36	88.24	.93	.77
Mill No. 26, Tennessee—													
Corn, Illinois........	13.87	26.0	7.97	3.60	71.26	2.08	1.22	30.2	9.25	4.19	82.73	2.42	1.41
Meal, cream..........	12.41	17.5	6.84	2.00	77.48	.60	.67	20.0	7.81	2.28	88.45	.69	.77
Mill No. 27, Tennessee—													
Corn, Middle West..	12.63	24.2	8.31	3.67	72.16	2.06	1.17	27.7	9.51	4.20	82.59	2.36	1.34
Meal, cream..........	12.54	18.7	7.72	2.31	75.74	.96	.73	21.4	8.82	2.64	86.60	1.10	.84
Mill No. 28, Tennessee—													
Corn, Middle West..	12.74	21.0	9.22	4.72	70.43	1.72	1.17	24.1	10.56	5.41	80.72	1.97	1.34
Meal, cream..........	11.97	15.4	7.47	1.44	77.87	.72	.53	17.5	8.48	1.63	88.47	.82	.60
Mill No. 29, Wisconsin—													
Corn.................	17.83	26.1	8.50	3.28	67.24	2.03	1.12	31.7	10.34	3.99	81.84	2.47	1.36
Meal, cream..........	15.18	15.6	6.56	.70	76.46	.73	.37	18.4	7.73	.83	90.14	.86	.44
Meal Maximum...	18.28	23.0	8.84	2.31	78.40	.96	.81	26.7	10.14	2.64	90.55	1.10	.92
Meal Minimum...	11.97	10.6	5.81	.70	72.41	.58	.35	12.2	6.80	.83	85.56	.67	.40
Meal **Average**....	**13.98**	**17.0**	**6.95**	**1.43**	**76.42**	**.70**	**.52**	**19.7**	**8.07**	**1.66**	**88.85**	**.82**	**.60**
Yellow corn and meal:													
Mill No. 30, Iowa—													
Corn.................	17.92	20.8	8.31	3.77	66.72	2.09	1.19	25.2	10.12	4.58	81.32	2.54	1.44
Meal, fine............	16.18	14.5	6.63	.75	75.63	.55	.26	17.3	7.91	.89	90.24	.65	.31
Meal, granular.......	15.54	14.0	7.94	.33	75.49	.46	.24	16.6	9.40	.39	89.39	.55	.27

TABLE 4.—*Composition of degerminated, bolted, roller-ground meal and of corn from which meal was milled*—Continued.

Product.	Analysis as received.							Analysis calculated to moisture-free basis.					
	Moisture.	Acidity.	Protein (N×6.25).	Fat.	Nitrogen-free extract.	Crude fiber.	Ash.	Acidity.	Protein (N×6.25).	Fat.	Nitrogen-free extract.	Crude fiber.	Ash.
Yellow corn and meal—Continued.													
Mill No. 18, Iowa—	*P.ct.*		*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*		*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*
Corn, Middle West..	16.75	19.7	8.53	3.68	67.63	2.14	.27 1	23.6	10.25	4.42	81.24	2.57	1.52
Meal, cream..........	17.85	19.0	7.37	1.47	71.98	.72	.61	23.1	8.98	1.79	87.62	.88	.73
Mill No. 31, Michigan—													
Corn, Middle West..	12.73	21.9	8.97	3.77	71.16	2.12	1.25	25.1	10.27	4.34	81.53	2.43	1.43
Meal, cream..........	13.33	19.2	7.50	1.81	76.02	.69	.65	22.2	8.65	2.09	87.72	.79	.75
Mill No. 32, Michigan—													
Corn, Middle West..	14.87	23.0	8.34	3.72	69.53	2.24	1.30	27.1	9.80	4.37	81.67	2.63	1.53
Meal, granular	14.71	17.9	7.47	.78	75.97	.59	.48	21.0	8.75	.92	89.08	.69	.56
Mill No. 24, New York—													
Corn, Middle West..	12.91	25.5	8.72	3.88	70.86	2.29	1.34	29.3	10.01	4.45	81.37	2.63	1.54
Meal, table...........	13.01	19.7	8.63	1.40	75.64	.76	.56	22.7	9.92	1.61	86.96	.87	.64
Mill No. 33, Wisconsin—													
Corn, Dakota........	16.87	31.0	8.56	3.69	67.65	2.10	1.13	37.3	10.29	4.44	81.39	2.52	1.36
Meal, granular.......	14.12	16.2	8.00	.59	76.40	.59	.30	18.8	9.32	.69	88.95	.69	.35
Meal, bolted.........	14.88	15.7	6.63	.82	76.64	.69	.34	18.4	7.79	.96	90.04	.81	.40
Meal Maximum...	17.85	19.7	8.63	1.81	76.64	.76	.65	23.1	9.92	2.09	90.24	.88	.75
Meal Minimum....	13.01	14.0	6.63	.33	71.98	.46	.24	16.6	7.79	.39	86.96	.55	.27
Meal **Average**	**14.95**	**17.0**	**7.52**	**.99**	**75.48**	**.63**	**.43**	**20.0**	**8.84**	**1.17**	**88.75**	**.74**	**.50**

The analyses calculated to the moisture-free basis show that the process invariably yielded a meal containing less acidity, protein, fat, fiber, and ash, as well as more nitrogen-free extract than the corn. The range in acidity of the white meal is from 10.6 to 23, and of the yellow meal from 14 to 19.7, in all cases calculated to the material as received.

The fact that the acidity and fat are much lower than in the corn shows superior keeping qualities. The tendency to spoilage is further diminished by drying, at least during the winter and spring when the corn carries an excessive amount of moisture. Without drying the meal may contain even more moisture than the corn, due to the tempering with steam or water to facilitate separation of the germ and bran. The keeping qualities of meal of this type are further brought out in the experiments described on subsequent pages (see Tables 8, 10, 12, and 14).

LOW GRADE OR "STANDARD" TABLE MEAL.

Analyses of low grade or "standard" table meal and of the corn from which the meal was milled appear in Table 5. This type of meal is a by-product of mills producing a higher grade of meal or grits or both and is intermediate between such products and the feed. While it differs greatly in composition, the average amounts of acidity, protein, fat, fiber and ash are more and of nitrogen-free extract less than in cream meal. As compared with the corn, it is sometimes richer and sometimes poorer in fat. This "standard" meal is consumed largely by the poorer classes in the South.

TABLE 5.—*Composition of low grade ("standard") table meal and of corn from which the meal was milled with removal of grits or high grade meal and feed.*

Product.	Analysis as received.							Analysis calculated to moisture-free basis.					
	Moisture.	Acidity.	Protein (N×6.25).	Fat.	Nitrogen-free extract.	Crude fiber.	Ash.	Acidity.	Protein. (N×6.25).	Fat.	Nitrogen-free extract.	Crude fiber.	Ash.
White corn and meal:													
Mill No. 19, Maryland—	*P. ct.*		*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*		*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
Corn, Middle West	14.71	21.2	8.31	3.68	70.04	2.09	1.17	24.9	9.74	4.31	82.13	2.45	1.37
Meal, standard	14.65	26.2	7.06	2.83	73.81	.80	.85	30.7	8.27	3.31	86.48	.94	1.00
Mill No. 11, Missouri—													
Corn	15.83	21.3	8.78	3.67	68.65	1.84	1.23	25.3	10.44	4.36	81.56	2.18	1.46
Meal, standard	10.01	24.1	9.97	4.34	72.31	1.80	1.57	26.7	11.07	4.82	80.37	2.00	1.74
Mill No. 22, Missouri—													
Corn, Middle West	15.19	24.2	8.81	3.54	69.20	1.92	1.34	28.4	10.39	4.17	81.59	2.27	1.58
Meal, standard	11.51	21.8	8.59	3.36	74.39	.99	1.16	24.6	9.72	3.80	84.05	1.12	1.31
Mill No. 23, Missouri—													
Corn	16.19	23.3	8.00	3.52	69.10	1.96	1.23	27.8	9.54	4.20	82.45	2.34	1.47
Meal, standard	13.42	20.8	8.15	3.96	72.05	1.12	1.30	24.0	9.42	4.58	83.20	1.30	1.50
Mill No. 37, Tennessee—													
Corn, Illinois	12.60	24.7	8.34	3.73	72.06	2.00	1.27	28.3	9.55	4.27	82.44	2.29	1.45
Meal, standard	14.03	44.5	9.15	5.26	68.26	1.74	1.56	51.8	10.65	6.12	79.40	2.02	1.81
Mill No. 26, Tennessee—													
Corn, Illinois	13.87	26.0	7.97	3.60	71.26	2.08	1.22	30.2	9.25	4.19	82.73	2.42	1.41
Meal, standard	12.10	19.7	7.94	3.48	74.33	.98	1.17	22.5	9.03	3.96	84.56	1.12	1.33
Mill No. 27, Tennessee—													
Corn	12.63	24.2	8.31	3.67	72.16	2.06	1.17	27.7	9.51	4.20	82.59	2.36	1.34
Meal, standard	12.03	23.2	8.62	3.61	73.15	1.44	1.15	26.4	9.79	4.10	83.16	1.64	1.31
Mill No. 28, Tennessee—													
Corn	12.74	21.0	9.22	4.72	70.43	1.72	1.17	24.1	10.56	5.41	80.72	1.97	1.34
Meal, standard	11.56	21.5	9.90	4.32	71.40	1.29	1.53	24.3	11.20	4.88	80.73	1.46	1.73
Meal Maximum	14.65	44.5	9.97	5.26	74.39	1.80	1.57	58.1	11.20	6.12	86.48	2.02	1.81
Minimum	10.01	19.7	7.05	2.83	68.26	.80	.85	22.5	8.27	3.31	79.40	.94	1.00
Average	**12.41**	**25.2**	**8.67**	**3.89**	**72.48**	**1.27**	**1.28**	**28.9**	**9.89**	**4.15**	**82.74**	**1.45**	**1.47**

GRITS.

Table 6 shows the composition of five samples of table grits and six samples of brewers' grits taken from mills in the Middle West. The difference in composition between the two classes lies chiefly in the lower percentage of fat in the brewers' grits.

TABLE 6.—*Composition of table and brewers' corn grits.*

Product.	Analysis of original material.							Analysis calculated to moisture-free basis.					
	Moisture.	Acidity.	Protein (N×6.25).	Fat.	Nitrogen-free extract.	Crude fiber.	Ash.	Acidity.	Protein (N×6.25).	Fat.	Nitrogen-free extract.	Crude fiber.	Ash.
Table grits:	*P. ct.*		*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*		*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
Mill No. 15, Indiana	14.12	15.0	7.41	0.86	76.64	0.61	0.36	17.5	8.63	1.00	89.24	0.71	0.42
Mill No. 16, Indiana	14.12	16.2	7.47	.73	76.70	.62	.36	18.9	8.69	.85	89.32	.72	.42
Mill No. 17, Iowa	14.20	15.6	8.50	.85	75.40	.58	.47	18.2	9.91	.99	87.87	.68	.55
Mill No. 11, Missouri	10.92	18.3	9.28	2.32	75.68	.88	.92	20.5	10.40	2.61	84.97	.99	1.03
Mill No. 23, Missouri	12.53	14.3	8.13	1.68	76.28	.79	.59	16.3	9.29	1.92	87.22	.90	.67
Maximum	14.20	18.3	9.28	2.32	76.70	.88	.92	20.5	10.40	2.61	89.32	.99	1.03
Minimum	10.92	14.3	7.41	.73	75.40	.58	.36	16.3	8.63	.85	84.97	.68	.42
Average	**13.18**	**15.9**	**8.16**	**1.29**	**76.13**	**.70**	**.54**	**18.3**	**9.38**	**1.47**	**87.73**	**.80**	**.62**
Brewers' grits:													
Mill No. 12, Illinois	13.42	13.1	7.78	.43	77.60	.54	.23	15.1	8.98	.50	89.62	.63	.27
Mill No. 13, Illinois	15.87	23.9	7.75	.72	74.63	.67	.36	28.3	9.21	.86	88.70	.80	.43
Mill No. 14, Illinois	14.11	14.8	7.12	.75	77.03	.65	.34	17.2	8.29	.87	89.69	.75	.40
Mill No. 41, Indiana	15.63	15.7	7.56	.69	75.28	.52	.32	18.6	8.95	.82	89.25	.61	.37
Mill No. 22, Missouri	13.80	14.1	8.22	.72	76.34	.59	.33	16.3	9.54	.83	88.56	.68	.39
Mill No. 29, Wisconsin	15.12	16.8	7.84	.72	75.22	.73	.37	19.8	9.23	.85	88.62	.86	.44
Maximum	15.87	23.9	8.22	.75	77.60	.73	.37	28.3	9.54	.87	89.69	.86	.44
Minimum	13.42	13.1	7.12	.43	74.63	.52	.23	15.1	8.29	.50	88.56	.61	.27
Average	**14.66**	**16.4**	**7.71**	**.67**	**76.01**	**.62**	**.33**	**19.2**	**9.03**	**.79**	**89.08**	**.72**	**.38**

As shown by the analyses in Table 1, grits contain less fat, fiber and ash, but more protein than meal of the same mill run, although the difference is not always well marked, especially as much of the cream meal may be classed as a kind of fine grits.

SPOILAGE OF MEAL.

It is well recognized that spoiled corn should not be used for table meal and that when good corn is used the corn or the product should be dried to insure keeping. Spoilage is most common during the spring which is designated by the trade as the "germinating season." At this season when the whole kernel is ready to germinate it is reasoned that the germ tissues in the meal also show a tendency toward activity. The relation of season to spoilage is more probably that of temperature. Meal should keep through the germinating season if held in cold storage. On the other hand, it will spoil in the winter months if it contains an excess of moisture and is kept in warm storage. That the presence of the germ in the meal increases the tendency to spoilage has been known in a general way to the trade and has been emphasized by Schindler, Black, and Alsberg and other investigators.

Other things equal, grits keep better than meal, and meal made from the horny part of the kernel better than that containing the floury part. Evidently the mechanical condition as well as the composition is an important factor in determining the keeping qualities.

RELATION OF MOISTURE CONTENT TO KEEPING QUALITY OF DEGERMINATED BOLTED ROLLER-GROUND MEAL.

These experiments were carried on in two series, the first with ton lots and the second with carload lots. The meal used in both series was ground during the month of May, 1913, at the mill of the American Hominy Company, Terre Haute, Indiana. Each lot of meal was divided into two parts, one of which was shipped to Savannah, Georgia, the other to Chicago, Illinois. At both places the meal was stored in public warehouses designed for products of this nature, sample bags being withdrawn from month to month for chemical analysis and tests as to quality. The analyses of the meal as ground were made at the Chicago Food and Drug Inspection Laboratory, as were also the analyses at the end of each period of the meal stored at that center. Analyses of the meal stored at Savannah were made at the Government food laboratory located in that city. In addition to the usual chemical determinations, the general appearance of the meal and the taste and flavor of the mush prepared from the meal were noted.

STORAGE EXPERIMENTS WITH TON LOTS OF MEAL MILLED MAY 7, 1913.

DESCRIPTION AND ANALYSES OF THE MEAL AS MILLED.

Five lots of 1 ton each were milled to contain percentages of moisture ranging from 11.41 to 16.86. Since the corn used, owing to the good quality of the crop of 1912 and the lateness of the season, was quite dry, the meal ground without any drying whatever (lot B) contained only 15.04 per cent of moisture. In order to secure one lot with a higher moisture content, such as would have been present in undried meal milled earlier in the season, water in addition to the amount usually employed for tempering was added to the corn. In this manner the percentage of moisture in lot A was raised to 16.86. It was recognized that meal thus prepared was not strictly comparable with that made without the addition of water from corn with a higher moisture content, and due allowance was made in interpreting the results.

TABLE 7.—*Composition of ton lots of degerminated, bolted, roller-ground corn meal, containing different amounts of moisture, as milled May 7, 1913, for use in storage experiments.*

Product.	Moisture.	Acidity.	Protein (N×6.25).	Fat.	Nitrogen-free extract.	Crude fiber.	Ash.
	Per cent.		*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Meal as milled:							
Lot A, undried, water added	16.86	14.7	6.53	0.71	75.13	0.49	0.28
Lot B, undried	15.04	14.0	6.50	.94	76.65	.52	.35
Lot C, medium dried	13.41	14.1	6.69	1.05	77.87	.59	.39
Lot D, medium dried	13.27	13.4	6.66	.80	78.32	.59	.36
Lot E, high dried	11.41	11.9	6.72	1.32	79.47	.62	.46
Moisture-free meal:							
Lot A, undried, water added	....	17.7	7.85	.86	90.36	.59	.34
Lot B, undried	....	16.5	7.65	1.11	90.22	.61	.41
Lot C, medium dried	....	16.3	7.73	1.21	89.92	.69	.45
Lot D, medium dried	....	15.5	7.68	.92	90.30	.68	.42
Lot E, high dried	....	13.4	7.58	1.49	89.71	.70	.52

Lots C, D, and E were dried to different degrees, the meal containing 13.41, 13.27, and 11.41 per cent of moisture, respectively. It should be noted that lots C and D contained practically the same amount of moisture and might be regarded as duplicates were it not that lot C was somewhat richer in fat and therefore more susceptible to spoilage.

Part of each lot was packed in 100-pound and part in 25-pound cotton bags, the weight in each case being accurately determined by standard scales. It was believed that the gain or loss in moisture during storage would furnish useful data in connection with the net weight amendment of the Food and Drugs Act, as well as for the special purposes of this investigation.

SHIPMENT AND STORAGE.

Shipment was made to Chicago and Savannah in ordinary freight cars with the larger lots of meal of the next series of experiments. The warehouse in Chicago was several stories high and of fireproof construction. The windows admitted some air but little sunlight, and the temperature responded slowly to outside changes. The Savannah warehouse was three stories high with board floors, and was exceptionally light and airy, the temperature of the air within and without being practically the same. Each lot of bags was separately piled, care being taken not to allow those with an extreme moisture content to come in contact with one another.

ANALYSES AND TESTS OF THE STORED MEAL.

The results of determinations of moisture, acidity, fat, and protein contents made at the end of each four weeks' period are given in Table 8. This table also gives notes as to the physical condition and permits comparison of the loss in weight and loss in moisture. The same general results were obtained at both Savannah and Chicago, and with both 100 and 25-pound bags.

Moisture.—Lots A and B show a steady loss of moisture and lot E a steady gain, while lots C and D remain practically constant. The changes in weight in most cases follow closely the changes in moisture.

Acidity.—Lots D and E in no case reached the limit 30, and lot C just barely reached that limit after several months' storage. Lot B slightly exceeded the limit after 16 weeks' storage, and lot A exceeded the limit in 12 weeks.

Fat.—There was no marked change except in the case of lot A where the percentage of fat diminished as the acidity increased.

Protein.—No significant change took place.

Taste and appearance.—Lot A was found to be musty after 20 weeks' storage. No deterioration was detected in any of the other samples.

TABLE 8.—*Analyses of degerminated, bolted, roller-ground corn meal containing different amounts of moisture, showing changes during storage; ton lots, milled May 7, 1913.*

Product.	Stored in 100-pound bags.						
	Moisture.	Acidity.	Protein (N×6.25).	Fat.	Change in weight.	Change in moisture.	Taste and appearance.
Meal stored at Chicago:	*Per cent.*		*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	
Lot A, undried, water added—							
When milled	16.86	14.7	6.53	0.71	....	....	Good.
Stored 4 weeks	15.72	20.5	....	.74	−0.50	−1.14	Do.
Stored 8 weeks	15.50	25.5	....	.67	−1.47	−1.36	Do.
Stored 12 weeks	15.52	35.6	....	.65	−1.83	−1.34	Do.
Stored 16 weeks	14.92	43.2	....	.42	−2.79	−1.94	Do.
Stored 20 weeks	14.75	44.3	6.37	.39	−2.51	−2.11	Musty
Stored 24 weeks	14.24	39.3	6.81	.44	−2.96	−2.62	Do.
Lot B, undried—							
When milled	15.04	14.0	6.50	.94	....	....	Good.
Stored 4 weeks	14.57	18.5	....	.95	− .12	− .47	Do.
Stored 8 weeks	14.61	23.7	....	.93	+ .28	− .43	Do.
Stored 12 weeks	14.78	28.0	....	.97	− .33	− .26	Do.
Stored 16 weeks	14.42	29.7	....	.91	− .06	− .62	Do.
Stored 20 weeks	14.32	31.3	6.38	.85	....	− .72	Do.
Stored 24 weeks	13.97	31.0	6.50	.87	....	−1.07	Do.
Lot C, medium dried—							
When milled	13.41	14.1	6.69	1.05	....	....	Do.
Stored 4 weeks	13.39	18.0	....	1.03	+ .15	− .02	Do.
Stored 8 weeks	13.57	23.5	....	1.08	+ .10	+ .16	Do.
Stored 12 weeks	13.98	28.0	....	1.11	+ .18	+ .57	Do.
Stored 16 weeks	13.65	29.2	....	1.02	+ .26	+ .24	Do.
Stored 20 weeks	13.76	29.8	6.78	1.02	....	+ .35	Do.
Stored 24 weeks	13.50	29.7	6.81	1.03	....	+ .09	Do.
Lot D, medium dried—							
When milled	13.27	13.4	6.66	.80	....	....	Do.
Stored 4 weeks	13.37	16.5	....	.76	+ .12	+ .10	Do.
Stored 8 weeks	13.69	20.0	....	.82	....	+ .40	Do.
Stored 12 weeks	13.86	22.5	....	.80	+ .63	+ .59	Do.
Stored 16 weeks	13.56	23.4	....	.79	....	+ .29	Do.
Stored 20 weeks	13.58	23.6	6.65	.73	+ .22	+ .31	Do.
Stored 24 weeks	13.36	21.7	6.72	.74	+ .31	+ .09	Do.
Lot E, high dried—							
When milled	11.41	11.9	6.72	1.32	....	....	Do.
Stored 4 weeks	12.15	14.5	....	1.30	+1.12	+ .74	Do.
Stored 8 weeks	12.58	19.0	....	1.32	+1.45	+1.17	Do.
Stored 12 weeks	12.87	23.0	....	1.30	+1.74	+1.46	Do.
Stored 16 weeks	12.55	23.7	....	1.24	+1.94	+1.14	Do.
Stored 20 weeks	12.80	24.3	6.66	1.29	....	+1.39	Do.
Stored 24 weeks	12.63	23.2	6.69	1.25	....	+1.22	Do.
Meal stored at Savannah:							
Lot A, undried, water added—							
When milled	16.86	14.7	6.53	.71	....	....	
Stored 4 weeks	14.92	27.0	7.06	.66	−2.50	−1.94	
Stored 8 weeks	13.48	30.0	6.92	.70	−3.00	−3.38	
Stored 12 weeks	13.18	31.0	6.83	.56	−3.45	−3.68	
Stored 16 weeks	13.21	33.1	7.00	.53	−3.81	−3.65	
Stored 20 weeks	13.76	26.5	6.94	.59	−3.38	−3.10	
Stored 24 weeks	13.85	26.0	6.74	.49	−3.77	−3.01	
Lot B, undried—							
When milled	15.04	14.0	6.50	.94	....	....	
Stored 4 weeks	14.25	24.2	6.75	.96	− .37	− .79	
Stored 8 weeks	13.04	25.0	6.66	.98	− .94	−2.00	
Stored 12 weeks	12.77	26.0	6.66	1.01	....	−2.27	
Stored 16 weeks	12.86	32.8	6.57	.94	−1.37	−2.18	
Stored 20 weeks	13.54	24.5	6.75	.96	−1.28	−1.50	
Stored 24 weeks	13.73	25.5	6.64	.94	−1.56	−1.31	
Lot C, medium dried—							
When milled	13.41	14.1	6.69	1.05	....	....	
Stored 4 weeks	13.10	24.0	6.75	1.03	−3.75	− .31	
Stored 8 weeks	12.25	24.0	6.66	1.05	− .62	−1.16	
Stored 12 weeks	12.04	23.5	6.92	1.13	− .96	−1.37	
Stored 16 weeks	12.59	31.9	6.97	1.05	− .79	− .82	
Stored 20 weeks	13.46	23.5	6.83	1.07	+ .38	+ .05	
Stored 24 weeks	13.22	24.0	6.91	1.13	−1.11	− .19	
Lot D, medium dried—							
When milled	13.27	13.4	6.66	.80	....	....	
Stored 4 weeks	13.15	20.0	6.87	.89	+ .19	− .12	
Stored 8 weeks	12.56	20.0	6.66	.79	− .25	− .71	
Stored 12 weeks	12.43	21.0	6.83	.87	− .19	− .84	
Stored 16 weeks	12.83	25.8	6.62	.77	− .19	− .44	
Stored 20 weeks	13.08	19.5	6.66	.75	+ .34	− .19	
Stored 24 weeks	13.15	18.2	6.74	.85	−1.61	− .12	

TABLE 8.—*Analyses of degerminated, bolted, roller-ground corn meal containing different amounts of moisture, etc.*—Continued.

Product.	Stored in 100-pound bags.						
	Moisture.	Acidity.	Protein (N×6.25).	Fat.	Change in weight.	Change in moisture.	Taste and appearance.
	Per cent.		*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	
Meal stored at Savannah—Continued.							
Lot E, high dried—							
When milled	11.41	11.9	6.72	1.32	....	....	
Stored 4 weeks	11.89	19.0	6.55	1.25	+1.13	+ .48	
Stored 8 weeks	11.51	19.5	6.39	1.30	....	+ .10	
Stored 12 weeks	11.55	20.5	6.75	1.37	+1.38	+ .14	
Stored 16 weeks	12.66	25.9	6.79	1.29	+1.34	+1.25	
Stored 20 weeks	12.78	19.5	6.79	1.25	+ .34	+1.37	
Stored 24 weeks	12.56	20.0	6.64	1.35	+1.78	+1.15	

Product.	Stored in 25-pound bags.					
	Moisture.	Acidity.	Protein (N×6.25).	Fat.	Change in weight.	Change in moisture.
	Per cent.		*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Meal stored at Chicago:						
Lot A, undried, water added—						
When milled	16.86	14.7	6.53	0.71	....	....
Stored 4 weeks	16.00	20.5	....	.70	−1.04	−0.86
Stored 8 weeks	15.39	25.7	....	.72	−1.83	−1.47
Stored 12 weeks	15.16	31.3	....	.73	−2.61	−1.70
Stored 16 weeks	14.37	32.5	....	.59	−3.26	−2.49
Stored 20 weeks	14.30	31.7	6.88	.60	−3.59	−2.56
Stored 24 weeks	13.84	32.0	6.91	.63	−3.39	−3.02
Lot B, undried—						
When milled	15.04	14.0	6.50	.94	....	....
Stored 4 weeks	14.52	18.5	....	.97	− .26	− .52
Stored 8 weeks	14.52	24.3	....	.90	− .39	− .52
Stored 12 weeks	14.55	28.3	....	.91	− .65	− .49
Stored 16 weeks	13.78	30.2	....	.89	−1.31	−1.26
Stored 20 weeks	13.89	29.6	6.47	.94	−1.50	−1.15
Stored 24 weeks	13.64	30.2	6.69	.93	−1.57	−1.40
Lot C, medium dried—						
When milled	13.41	14.1	6.69	1.05	....	....
Stored 4 weeks	13.44	18.5	....	1.03	+ .73	+ .03
Stored 8 weeks	13.67	23.5	....	1.06	+ .59	+ .26
Stored 12 weeks	13.88	28.0	....	1.10	+ .65	+ .47
Stored 16 weeks	13.51	28.7	....	1.02	+ .13	+ .10
Stored 20 weeks	13.47	29.8	6.72	1.02	− .06	+ .06
Stored 24 weeks	13.22	30.0	6.75	1.01	+ .59	− .19
Lot D, medium dried—						
When milled	13.27	13.4	6.66	.80	....	....
Stored 4 weeks	13.38	16.0	....	.80	+ .78	+ .11
Stored 8 weeks	13.57	20.0	....	.75	+ .26	+ .30
Stored 12 weeks	13.71	23.0	....	.81	− .07	+ .44
Stored 16 weeks	13.23	23.2	....	.75	.00	− .04
Stored 20 weeks	13.42	23.3	6.66	.81	− .20	+ .15
Stored 24 weeks	13.22	22.0	6.97	.74	+ .20	− .05
Lot E, high dried—						
When milled	11.41	11.9	6.72	1.32	....	....
Stored 4 weeks	12.22	15.0	....	1.29	+1.30	+ .81
Stored 8 weeks	12.68	19.0	....	1.22	+1.50	+1.27
Stored 12 weeks	13.08	23.0	....	1.36	+1.37	+1.67
Stored 16 weeks	12.66	23.7	....	1.24	+1.31	+1.25
Stored 20 weeks	12.73	24.3	6.59	1.30	− .46	+1.32
Stored 24 weeks	12.56	25.0	6.59	1.28	+1.95	+1.15
Meal stored at Savannah:						
Lot A, undried, water added—						
When milled	16.86	14.7	6.53	.71	....	....
Stored 4 weeks	14.96	29.5	7.06	.62	−2.47	−1.90
Stored 8 weeks	13.33	28.5	6.92	.65	−3.78	−3.53
Stored 12 weeks	13.06	31.0	6.92	.60	−4.29	−3.78
Stored 16 weeks	13.46	34.7	6.73	.48	−4.17	−3.40
Stored 20 weeks	14.06	28.5	6.66	.48	−3.90	−2.80
Stored 24 weeks	....	....	....	....	....	....

TABLE 8.—*Analyses of degerminated, bolted, roller-ground corn meal containing different amounts of moisture, etc.*—Continued.

Product.	Stored in 25-pound bags.					
	Moisture.	Acidity.	Protein (N×6.25).	Fat.	Change in weight.	Change in moisture.
Meal stored at Savannah—Continued.	*Per cent.*		*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Lot B, undried—						
When milled	15.04	14.0	6.50	0.94	....	....
Stored 4 weeks	14.09	24.0	6.69	.93	−1.17	−0.95
Stored 8 weeks	12.83	25.0	6.66	1.03	−1.76	−2.21
Stored 12 weeks	12.39	26.0	6.75	1.00	−2.08	−2.65
Stored 16 weeks	13.69	31.7	6.69	.97	−5.47	−1.35
Stored 20 weeks	13.88	23.5	6.54	.95	−1.89	−1.16
Stored 24 weeks	....	....	....	....	....	....
Lot C, medium dried—						
When milled	13.41	14.1	6.69	1.05	....	....
Stored 4 weeks	13.27	23.5	6.73	1.05	− .52	− .14
Stored 8 weeks	12.23	23.2	6.70	1.00	−1.79	−1.18
Stored 12 weeks	12.02	25.2	6.75	1.10	− .37	−1.39
Stored 16 weeks	12.89	30.0	6.71	1.10	− .00	− .52
Stored 20 weeks	13.73	26.5	6.83	1.05	+ .07	+ .32
Stored 24 weeks	....	....	....	....	....	....
Lot D, medium dried—						
When milled	13.27	13.4	6.66	.80	....	....
Stored 4 weeks	13.13	20.0	6.81	.82	− .65	− .14
Stored 8 weeks	12.21	20.0	6.83	.85	− .65	−1.06
Stored 12 weeks	12.26	20.2	6.92	.85	− .78	−1.01
Stored 16 weeks	13.60	23.5	6.53	.81	− .58	+ .33
Stored 20 weeks	13.69	18.5	6.66	.81	− .26	+ .42
Stored 24 weeks	....	....	....	....	....	....
Lot E, high dried—						
When milled	11.41	11.9	6.72	1.32	....	....
Stored 4 weeks	12.18	18.5	6.50	1.31	+ .39	+ .77
Stored 8 weeks	11.32	20.2	6.44	1.33	+ .91	− .09
Stored 12 weeks	11.62	20.0	6.56	1.33	+ .80	+ .21
Stored 16 weeks	12.81	24.8	6.71	1.34	+1.04	+1.40
Stored 20 weeks	13.10	21.0	6.54	1.34	+1.50	+1.69
Stored 24 weeks	....	....	....	....	....	....

STORAGE EXPERIMENTS WITH CARLOAD LOTS OF MEAL MILLED MAY 23, 1913.

DESCRIPTION AND ANALYSES OF THE MEAL AS MILLED.

This experiment was carried out with carload lots (40 tons) of undried and highly dried meal. The meal was packed in 100-pound cotton sacks. As it was impracticable to mix thoroughly all of the meal of each lot, one ton (20 bags) was taken out for subsequent sampling, turned over on a floor with a shovel until uniform, and rebagged. One of these bags furnished the sample at the end of each period at each of the cities where the meal was stored. In both the cars and storage warehouse these sample bags were kept in the middle of the pile with bags of the same lot on all sides. Analyses of the meal when milled appear in Table 9.

TABLE 9.—*Composition of carload lots of degerminated, bolted, roller-ground corn meal, as milled with and without drying, May 23, 1913, for use in storage experiments.*

Product.	Moisture.	Acidity.	Protein (N×6.25).	Fat.	Nitrogen-free extract.	Crude fiber.	Ash.
Meal as milled:	*P. ct.*		*Per cent.*	*P. ct.*	*Per cent.*	*P. ct.*	*P. ct.*
Lot A, undried	15.73	16.2	7.12	1.02	75.19	0.51	0.43
Lot B, high dried	9.86	13.0	7.46	1.16	80.37	.67	.48
Moisture-free meal:							
Lot A, undried	....	19.2	8.45	1.21	89.22	.61	.51
Lot B, high dried	....	14.4	8.28	1.29	89.16	.74	.53

SHIPMENT AND STORAGE.

Each lot was divided into two parts and the two half lots shipped in the same car with the meal of the preceding experiment to Savannah and Chicago, where it was stored as already described.

ANALYSES AND TESTS OF THE STORED MEAL.

Determinations of moisture, acidity, fat, and protein were made at intervals of four weeks. The changes in weight, taste, and appearance were also recorded (Table 10).

Moisture.—Lot A showed a loss in moisture which was somewhat greater in Savannah than in Chicago, due either to the hotter climate or to the nature of the warehouse, or both. Lot B gained about the same amount at both places. The gain or loss of moisture was practically the same as the gain or loss in weight.

Acidity.—Lot A reached the limit 30 in 12 weeks at Chicago, and in 8 weeks at Savannah. The acidity of lot B after 24 weeks was only 21.8 and 19.0, respectively, at the two cities.

Fat.—The percentage of fat in lot A slowly diminished in both cities, but that of lot B did not change perceptibly. In all of the experiments, whenever there was a great increase in acidity or spoilage, there was a diminution of fat, due doubtless to the formation of ether-insoluble oxidation products.

Protein.—The changes were insignificant.

Taste and appearance.—In no case was there evidence of spoilage, even at the end of the experiment.

TABLE 10.—*Analyses of degerminated, bolted, roller-ground corn meal, milled with and without drying, showing changes during storage; carload lots, milled May 23, 1913, stored in 100-pound bags.*

Product.	Moisture.	Acidity.	Fat.	Protein (N×6.25).	Change in weight.	Change in moisture.	Taste and appearance.
Meal stored at Chicago:							
Lot A, undried—	*P. ct.*		*P. ct.*	*Per cent.*	*P. ct.*	*P. ct.*	
When milled	15.73	16.2	1.02	7.12	....	....	Good.
Stored 4 weeks	15.22	22.7	.98	....	−0.33	−0.51	Do.
Stored 8 weeks	15.68	28.1	.97	....	− .36	− .05	Do.
Stored 12 weeks	15.44	33.2	1.00	....	− .48	− .29	Do.
Stored 16 weeks	14.70	40.7	.78	....	− .93	−1.03	Do.
Stored 20 weeks	14.53	40.5	.81	7.19	−1.39	−1.20	Do.
Stored 24 weeks	14.20	42.4	.74	7.22	−1.64	−1.53	Do.
Lot B, high dried—							
When milled	9.86	13.0	1.16	7.46	....	....	Do.
Stored 4 weeks	9.90	15.6	1.18	....	+ .36	+ .04	Do.
Stored 8 weeks	10.88	17.3	1.17	....	+ .95	+1.02	Do.
Stored 12 weeks	10.94	18.7	1.25	....	+1.12	+1.08	Do.
Stored 16 weeks	11.07	20.5	1.17	....	+1.48	+1.21	Do.
Stored 20 weeks	11.20	20.8	1.16	7.43	+1.39	+1.34	Do.
Stored 24 weeks	10.96	21.8	1.18	7.53	+1.37	+1.10	Do.
Meal stored at Savannah:							
Lot A, undried—							
When milled	15.73	16.2	1.02	7.12	....	....	Do.
Stored 4 weeks	15.35	24.0	1.06	6.87	− .51	− .38	Do.
Stored 8 weeks	14.16	32.5	.99	7.10	−1.08	−1.57	Do.
Stored 12 weeks	13.53	32.7	.92	7.01	−1.80	−2.20	Do.
Stored 16 weeks	13.70	32.8	.91	7.31	−2.30	−2.03	Do.
Stored 20 weeks	13.50	29.0	.84	6.91	−2.83	−2.23	Do.
Stored 24 weeks	13.23	32.0	.90	7.00	−3.55	−2.50	Do.
Lot B, high dried—							
When milled	9.86	13.0	1.16	7.46	....	....	Do.
Stored 4 weeks	10.25	15.0	1.33	7.51	+ .48	+ .39	Do.
Stored 8 weeks	9.75	18.0	1.30	7.53	+1.23	− .11	Do.
Stored 12 weeks	10.30	19.0	1.29	7.58	+1.36	+ .44	Do.
Stored 16 weeks	10.74	19.3	1.21	7.56	+ .98	+ .88	Do.
Stored 20 weeks	11.22	16.5	1.27	7.26	+1.86	+1.36	Do.
Stored 24 weeks	11.10	19.0	1.23	7.18	+1.65	+1.24	Do.

COMPARATIVE KEEPING QUALITY OF WHOLE-KERNEL STONE-GROUND MEAL AND DEGERMINATED BOLTED ROLLER-GROUND MEAL.

In this investigation a comparison in regard to fat content was made of the keeping quality of meal of the extreme types, ground from the same corn and containing practically the same amounts of moisture. The experiments were carried out in two series, the first with meal milled in December, in parallel lots, dried to different degrees so as to contain from less than 11 to over 19 per cent of moisture, the second with meal ground in April without drying.

The whole-kernel meal was ground in an under-runner bevel mortise-geared buhr mill which was set up for the purpose at the Terre Haute plant of the American Hominy Company. The mill was adjusted to yield a fine, soft meal, such as is preferred by the southern trade, nothing being added to the corn and nothing taken away. The degerminated meal was the usual somewhat granular product of the mill known in the trade as "cream meal." The corn used was No. 3 white dent of the crop of 1913. The quality was quite poor, much inferior to that of the preceding year, which was exceptionally good. It thus appears that in the experiments of the two years the extremes in quality were encountered.

In all the experiments the stream of cleaned corn was divided, part going to the roller system and part to the buhr stones. The bags that received each kind of meal were numbered consecutively and the process so regulated that the meal of the two kinds in bags bearing the same number was from the same corn. As the capacity of the buhr mill was much less than that of the roller system it was necessary to draw the corn for the whole-kernel meal from the divided stream into bags arranged in the proper order and continue the grinding, after the cream meal was milled and sacked.

As in the experiments of the preceding year, it was impracticable to mix all of the meal in each lot. Accordingly ton portions were taken out, mixed, analyzed, and bagged in specially marked sacks, one of which was used for the tests at the end of each storage period. Care was taken that these sublots for sampling, representing the two kinds of meal of the same moisture content, were from the bags bearing the same numbers and therefore were comparable not only as to moisture, but also as to corn.

STORAGE EXPERIMENTS WITH PARALLEL LOTS OF WHOLE-KERNEL AND DEGERMINATED MEAL, OF DIFFERENT DEGREES OF DRYNESS, MILLED DECEMBER, 1913.

DESCRIPTION AND ANALYSES OF THE MEAL AS MILLED.

This experiment involved the serious difficulty of drying both kinds of meal of each pair of the series so that they should be alike as to corn and moisture. As the drying apparatus of the stone system differed from that of the roller system in kind and capacity, it was only after repeated trials that suitable lots were secured. A laboratory was set up at the mill. Here tests for moisture and acidity were made on the meal immediately after milling, the remainder of the analyses being finished at the Chicago Food and Drug Inspection Laboratory.

The analyses in Table 11 represent the six parallel lots finally secured. It will be noted that the percentage of moisture in the two kinds of meal of each pair are reasonably close together, thus permitting satisfactory comparison of the results obtained after storage; furthermore, that the range in moisture (less than 11 to over 19 per cent) is sufficiently great to cover the trade conditions. As the corn varied from day to day, it was found impossible to keep the composition of the meal of the different lots uniform. This, however, seemed unnecessary so long as the two kinds of meal of each pair were from the same corn and of practically the same moisture content.

TABLE 11.—*Composition of carload lots of corn meal containing different amounts of moisture, as milled December, 1913, and used in storage experiments.*

Product.	Whole-kernel, stone-ground meal.						
	Moisture.	Acidity.	Protein (N×6.25).	Fat.	Nitrogen-free extract.	Crude fiber.	Ash.
Meal as milled:	*P. ct.*		*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
Lot A, undried	19.27	23.1	8.56	3.26	66.06	1.75	1.10
Lot B, extra low dried	17.25	28.5	8.76	3.45	67.71	1.73	1.10
Lot C, low dried	15.71	19.9	9.00	3.47	68.95	1.79	1.08
Lot D, medium dried	13.44	21.3	9.16	3.71	70.42	2.06	1.21
Lot E, high dried	12.25	24.6	9.44	3.55	71.65	1.95	1.16
Lot F, extra high dried	10.79	21.8	9.82	3.71	72.42	2.03	1.23
Moisture-free meal:							
Lot A, undried	....	27.6	10.60	4.04	81.83	2.17	1.36
Lot B, extra low dried	....	34.4	10.59	4.17	81.82	2.09	1.33
Lot C, low dried	....	23.6	10.68	4.12	81.80	2.12	1.28
Lot D, medium dried	....	24.6	10.58	4.29	81.34	2.39	1.40
Lot E, high dried	....	28.0	10.76	4.05	81.65	2.22	1.32
Lot F, extra high dried	....	24.4	11.01	4.16	81.17	2.28	1.38

Product.	Degerminated, bolted, roller-ground meal.						
	Moisture.	Acidity.	Protein (N×6.25).	Fat.	Nitrogen-free extract.	Crude fiber.	Ash.
Meal as milled:	*P. ct.*		*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
Lot A, undried	19.20	16.0	7.38	0.67	71.94	0.46	0.32
Lot B, extra low dried	17.73	17.6	7.50	.83	73.01	.57	.36
Lot C, low dried	15.72	13.8	7.38	.75	75.25	.56	.34
Lot D, medium dried	13.78	13.3	7.28	1.05	76.81	.64	.44
Lot E, high dried	12.91	13.0	7.41	.92	77.73	.60	.43
Lot F, extra high dried	11.26	13.9	7.25	1.06	79.31	.70	.42
Moisture-free meal:							
Lot A, undried	....	19.8	9.14	.83	89.06	.57	.40
Lot B, extra low dried	....	21.4	9.12	1.01	88.74	.69	.44
Lot C, low dried	....	16.4	8.76	.89	89.29	.66	.40
Lot D, medium dried	....	15.4	8.45	1.22	89.08	.74	.51
Lot E, high dried	....	14.9	8.51	1.06	89.25	.69	.49
Lot F, extra high dried	....	15.7	8.17	1.19	89.38	.79	.47

SHIPMENT AND STORAGE.

Half of each lot was shipped to Savannah and half to New Orleans, the analyses being made from month to month in the Government laboratories located in these cities. Each of the three cars destined for each city contained two parallel lots—that is to say, two half lots of whole-kernel meal and two of cream meal, representing two degrees of dryness. Care was taken not to allow the two kinds of meal, or meal of the same kind with extreme moisture content, to come in contact either in the car or the storage warehouse, also to so bury the bags for analysis in the piles that they should be surrounded by bags of the same lot on all sides. The storage warehouse at Savannah was similar to that used in the preceding experiment, while that at New Orleans was a large, modern structure of several stories, dimly lighted but quite well ventilated.

ANALYSES AND TESTS OF THE STORED MEAL.

The analyses shown in Table 12 are the most instructive of all those given in this bulletin and show conclusively the superior keeping qualities of degerminated meal.

Moisture.—The lots with high moisture, i. e., A, B, and C, regardless of the kind of meal, lost weight during storage, while the drier lots, D, E, and F, in most instances gained. In cases where the meal heated the loss in weight was not only considerable but noticeably greater than the loss in moisture, indicating that carbon dioxid was given off in appreciable amount.

Acidity.—The whole-kernel meal, even when dried to less than 11 per cent of moisture, became sufficiently acid to exceed the limit of 30 in from four to eight weeks and finally reached from two to over three times that limit. On the other hand, the degerminated meal gained slowly in acidity, the limit being exceeded in sixteen weeks only in lot B stored at New Orleans. The highest acidity that was reached in the degerminated meal of lots C, D, E, and F, which contained 15.72 to 11.26 per cent of moisture at the outset, was 30.1 and that only after 28 weeks' storage.

TABLE 12.—*Comparative analyses of whole-kernel, stone-ground corn meal and degerminated, bolted, roller-ground corn meal, containing different amounts of moisture, showing changes during storage; carload lots, milled December, 1913, and stored in 100-pound bags.*

Product.	Whole-kernel, stone-ground meal.						
	Moisture.	Acidity.	Protein (N×6.25).	Fat.	Change in weight.	Change in moisture.	Taste and appearance.
Meal stored at New Orleans:							
Lot A, undried—	*Per ct.*		*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	
When milled	19.27	23.1	8.56	3.26	....	....	Good.
Stored 4 weeks	14.73	83.6	9.28	2.61	−6.81	−4.54	Hot, musty, caked.
Stored 8 weeks	14.56	81.2	9.06	2.39	−7.50	−4.71	Rancid, caked, dark.
Stored 12 weeks	13.75	81.0	9.22	2.39	−8.00	−5.52	Do.
Stored 16 weeks	14.02	89.6	8.97	2.47	−7.70	−5.25	Do.
Stored 20 weeks	13.80	92.7	9.16	2.16	−8.22	−5.47	Do.
Stored 24 weeks	13.50	93.0	8.94	2.41	−7.94	−5.77	Do.
Stored 28 weeks	13.27	88.2	9.25	2.39	−8.67	−6.00	Do.
Lot B, extra low dried—							
When milled	17.25	28.5	8.76	3.45	....	....	Good.
Stored 4 weeks	17.17	42.0	8.72	3.49	− .34	− .08	Musty.
Stored 8 weeks	13.70	95.8	9.09	2.85	−5.22	−3.55	Hot, rancid, caked.
Stored 12 weeks	13.60	97.7	9.16	2.85	−5.27	−3.65	Rancid, caked.
Stored 16 weeks	13.80	103.0	8.97	2.92	−4.90	−3.45	Do.
Stored 20 weeks	13.68	107.2	9.09	2.62	−5.06	−3.57	Do.
Stored 24 weeks	13.45	107.6	9.12	2.96	−5.31	−3.80	Do.
Stored 28 weeks	13.19	107.6	9.13	2.86	−5.39	−4.06	Do.
Lot C, low dried—							
When milled	15.71	19.9	9.00	3.47	....	....	Good.
Stored 4 weeks	15.18	28.9	8.76	3.40	− .27	− .53	Do.
Stored 8 weeks	15.25	42.0	9.15	3.47	− .59	− .46	Do.
Stored 12 weeks	14.75	49.7	9.06	3.43	−1.09	− .96	Do.
Stored 16 weeks	14.94	59.7	8.94	3.43	− .73	− .77	Rancid.
Stored 20 weeks	13.86	86.7	9.09	3.26	−2.31	−1.85	Rancid, warm, lumpy.
Stored 24 weeks	12.87	93.0	9.15	2.75	−3.51	−2.84	Do.
Stored 28 weeks	12.34	104.1	9.19	2.50	−4.01	−3.37	Do.
Lot D, medium dried—							
When milled	13.44	21.3	9.16	3.71	....	....	Good.
Stored 4 weeks	13.61	31.5	9.12	3.55	+ .37	+ .17	Do.
Stored 8 weeks	13.78	39.2	9.06	3.62	+ .33	+ .34	Do.
Stored 12 weeks	13.68	47.9	9.19	3.53	+ .22	+ .24	Do.
Stored 16 weeks	13.64	53.0	8.97	3.56	+ .47	+ .20	Rancid.
Stored 20 weeks	13.56	69.5	9.00	3.60	+ .52	+ .12	Do.
Stored 24 weeks	13.26	76.9	9.15	3.58	+ .02	− .18	Do.
Stored 28 weeks	12.60	87.2	9.19	3.61	− .20	− .84	Do.
Lot E, high dried—							
When milled	12.25	24.6	9.44	3.55	....	....	Good.
Stored 4 weeks	12.43	39.0	9.25	3.55	+ .11	+ .18	Do.
Stored 8 weeks	12.55	50.0	9.44	3.54	+ .14	+ .30	Do.
Stored 12 weeks	12.47	61.6	9.12	3.56	+ .06	+ .22	Do.
Stored 16 weeks	12.48	71.0	9.22	3.66	+ .34	+ .23	Rancid.
Stored 20 weeks	12.64	93.4	9.44	3.54	+ .45	+ .39	Do.
Stored 24 weeks	12.38	90.2	9.34	3.50	+ .25	+ .13	Do.
Stored 28 weeks	12.21	105.5	9.50	3.55	+ .36	− .04	Do.
Lot F, extra high dried—							
When milled	10.79	21.8	9.82	3.71	....	....	Good.
Stored 4 weeks	10.95	26.8	9.62	3.72	+ .14	+ .16	Do.
Stored 8 weeks	11.34	37.4	9.59	3.68	+ .86	+ .55	Do.
Stored 12 weeks	11.13	44.8	9.75	3.62	+ .86	+ .34	Do.
Stored 16 weeks	11.57	55.6	9.72	3.59	+1.14	+ .78	Do.
Stored 20 weeks	11.55	72.5	9.81	3.51	+1.44	+ .76	Rancid.
Stored 24 weeks	11.47	86.5	9.69	3.69	+1.28	+ .68	Do.
Stored 28 weeks	11.43	86.7	9.63	3.55	+1.20	+ .64	Do.
Meal stored at Savannah:							
Lot A, undried—							
When milled	19.23	23.1	8.56	3.26	....	....	Good.
Stored 4 weeks	14.10	61.0	8.25	2.10	−7.52	−5.13	Warm, musty, caked.
Stored 8 weeks	14.27	69.3	8.79	2.40	−7.27	−4.96	Musty, caked.
Stored 12 weeks	13.77	64.0	8.55	2.31	−7.46	−5.46	Do.
Stored 16 weeks	14.16	64.0	9.06	2.17	−7.77	−5.07	Do.
Stored 20 weeks	13.60	77.0	8.66	2.33	−8.27	−5.63	Do.
Stored 24 weeks	13.90	77.0	8.66	1.95	−8.58	−5.33	Do.
Stored 28 weeks	12.78	84.0	8.84	2.11	−9.29	−6.45	Do.

TABLE 12.—*Comparative analyses of whole-kernel, stone-ground corn meal and degerminated, bolted, roller-ground corn meal, etc.*—Continued.

Product.	Whole-kernel, stone-ground meal.						
	Moisture.	Acidity.	Protein (N×6.25).	Fat.	Change in weight.	Change in moisture.	Taste and appearance.
Meal stored at Savannah—Contd.							
Lot B, extra low dried—	*Per ct.*		*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	
When milled	17.25	28.5	8.76	3.45	....	....	Good.
Stored 4 weeks	16.51	35.0	8.25	3.00	− .71	− .74	No record.
Stored 8 weeks	14.44	74.0	8.51	2.38	−4.08	−2.81	Warm.
Stored 12 weeks	13.87	77.0	8.43	2.60	−4.96	−3.38	Caked.
Stored 16 weeks	14.24	78.5	8.71	2.41	−4.58	−3.01	Do.
Stored 20 weeks	13.63	90.5	9.11	2.22	−5.48	−3.62	Do.
Stored 24 weeks	13.43	91.0	8.75	2.13	−6.02	−3.82	Do.
Stored 28 weeks	12.78	94.5	8.75	2.15	−6.27	−4.47	Do.
Lot C, low dried—							
When milled	15.71	19.9	9.00	3.47	....	....	Good.
Stored 4 weeks	15.08	22.4	8.65	3.45	− .46	− .63	Do.
Stored 8 weeks	14.88	34.0	8.60	3.40	− .77	− .83	Do.
Stored 12 weeks	14.88	43.5	8.60	3.47	− .90	− .83	Do.
Stored 16 weeks	14.48	46.0	8.78	3.32	−1.15	−1.23	Do.
Stored 20 weeks	13.47	74.0	9.11	3.38	−2.27	−2.24	Warm, caked.
Stored 24 weeks	12.48	81.2	8.75	3.23	−3.40	−3.23	Caked.
Stored 28 weeks	12.41	88.3	8.39	2.55	−4.08	−3.30	Do.
Lot D, medium dried—							
When milled	13.44	21.3	9.16	3.71	....	....	Good.
Stored 4 weeks	13.30	17.5	8.86	3.70	+ .11	− .14	No record.
Stored 8 weeks	13.48	36.3	8.87	3.57	+ .11	+ .04	Do.
Stored 12 weeks	13.56	39.0	8.79	3.50	+ .21	+ .12	Do.
Stored 16 weeks	13.45	44.0	8.97	3.69	+ .34	+ .01	Do.
Stored 20 weeks	13.28	65.5	9.11	3.80	− .21	− .16	Do.
Stored 24 weeks	12.99	70.5	9.02	3.50	− .40	− .45	Do.
Stored 28 weeks	12.54	76.7	8.17	3.80	− .71	− .90	Do.
Lot E, high dried—							
When milled	12.25	24.6	9.44	3.55	....	....	Good.
Stored 4 weeks	11.82	24.3	9.04	3.60	+ .05	− .43	No record.
Stored 8 weeks	12.67	45.5	8.87	3.58	+ .27	+ .42	Do.
Stored 12 weeks	12.60	53.0	8.87	3.72	+ .11	+ .35	Do.
Stored 16 weeks	12.46	56.0	8.87	3.76	+ .58	+ .21	Do.
Stored 20 weeks	12.58	77.0	9.11	3.68	+ .17	+ .33	Do.
Stored 24 weeks	12.35	88.5	9.11	3.79	− .02	+ .10	Do.
Stored 28 weeks	12.15	99.5	8.53	3.54	+ .02	− .10	Do.
Lot F, extra high dried—							
When milled	10.79	21.8	9.82	3.71	....	....	Good.
Stored 4 weeks	10.39	17.5	9.63	3.63	+ .64	− .40	No record.
Stored 8 weeks	11.08	30.5	9.02	3.59	+ .98	+ .29	Do.
Stored 12 weeks	11.27	39.0	9.50	3.78	+ .92	+ .48	Do.
Stored 16 weeks	11.32	46.5	9.68	3.62	+1.16	+ .53	Do.
Stored 20 weeks	11.51	70.5	9.64	3.76	+1.23	+ .72	Do.
Stored 24 weeks	11.45	73.5	9.56	3.55	+1.05	+ .66	Do.
Stored 28 weeks	11.54	83.0	9.56	3.58	+1.20	+ .75	Do.

Product.	Degerminated, bolted, roller-ground meal.						
	Moisture.	Acidity.	Protein (N×6.25).	Fat.	Change in weight.	Change in moisture.	Taste and appearance.
Meal stored at New Orleans:							
Lot A, undried—	*Per ct.*		*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	
When milled	19.20	16.0	7.38	0.69	....	....	Good.
Stored 4 weeks	19.21	22.0	7.60	.60	−0.33	+0.01	Warm, musty.
Stored 8 weeks	16.72	16.2	7.72	.26	−3.59	−2.48	Musty, lumpy, pink.
Stored 12 weeks	16.58	16.1	7.75	.25	−3.78	−2.62	Do.
Stored 16 weeks	16.68	17.3	7.22	.21	−3.61	−2.52	Do.
Stored 20 weeks	16.20	17.7	7.62	.22	−4.11	−3.00	Do.
Stored 24 weeks	15.99	18.4	7.13	.16	−3.87	−3.21	Do.
Stored 28 weeks	15.77	18.8	7.81	.20	−4.23	−3.43	Do.
Lot B, extra low dried—							
When milled	17.73	17.6	7.50	.83	....	....	Good.
Stored 4 weeks	17.37	19.2	7.60	.85	− .42	− .36	Do.
Stored 8 weeks	16.89	25.1	7.56	.77	−1.00	− .84	Slighty musty.
Stored 12 weeks	16.23	28.0	7.56	.76	−1.50	−1.50	Good.
Stored 16 weeks	16.09	34.5	7.31	.63	−1.40	−1.64	Do.
Stored 20 weeks	15.58	41.7	7.66	.36	−2.42	−2.15	Stale, lumpy.
Stored 24 weeks	15.22	37.6	7.78	.31	−2.75	−2.51	Musty, lumpy.
Stored 28 weeks	14.98	41.2	7.81	.28	−3.44	−2.75	Do.

TABLE 12.—*Comparative analyses of whole-kernel, stone-ground corn meal and degerminated, bolted, roller-ground corn meal, etc.*—Continued.

Product.	Degerminated, bolted, roller-ground meal.						
	Moisture.	Acidity.	Protein (N×6.25).	Fat.	Change in weight.	Change in moisture.	Taste and appearance.
Meal stored at New Orleans—Con.							
Lot C, low dried—	*Per ct.*		*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	
When milled	15.72	13.8	7.38	0.75	....	....	Good.
Stored 4 weeks	15.57	16.1	7.35	.70	−0.14	−0.15	Do.
Stored 8 weeks	15.51	18.0	7.40	.74	− .45	− .21	Do.
Stored 12 weeks	15.29	18.7	7.44	.77	− .80	− .43	Do.
Stored 16 weeks	15.45	19.6	7.28	.74	− .30	− .27	Do.
Stored 20 weeks	15.40	24.8	7.38	.72	− .53	− .32	Stale.
Stored 24 weeks	15.23	25.9	7.44	.76	− .44	− .49	Do.
Stored 28 weeks	14.82	28.9	7.63	.69	−1.51	− .90	Do.
Lot D, medium dried—							
When milled	13.78	13.3	7.28	1.05	....	....	Good.
Stored 4 weeks	14.61	16.4	7.25	1.04	− .14	+ .83	Do.
Stored 8 weeks	14.39	15.7	7.31	1.04	+ .56	+ .61	Do.
Stored 12 weeks	14.46	18.1	7.31	1.01	+ .66	+ .68	Do.
Stored 16 weeks	14.39	19.2	7.09	1.04	+ .80	+ .61	Do.
Stored 20 weeks	14.43	25.7	7.28	1.03	+ .37	+ .65	Do.
Stored 24 weeks	14.54	24.7	7.19	1.02	+ .36	+ .76	Do.
Stored 28 weeks	14.23	30.1	7.25	1.00	+ .65	+ .45	Do.
Lot E, high dried—							
When milled	12.91	13.0	7.41	.92	....	....	Do.
Stored 4 weeks	13.20	14.5	7.32	.95	+ .23	+ .29	Do.
Stored 8 weeks	13.42	14.5	7.31	.93	+ .70	+ .51	Do.
Stored 12 weeks	13.39	14.9	7.38	.96	+ .61	+ .48	Do.
Stored 16 weeks	13.62	16.3	7.37	.96	+ .95	+ .71	Do.
Stored 20 weeks	13.83	22.1	7.25	.96	+1.16	+ .92	Do.
Stored 24 weeks	13.58	19.6	7.19	.99	+1.08	+ .67	Do.
Stored 28 weeks	13.54	26.6	7.38	.92	+1.08	+ .63	Do.
Lot F, extra high dried—							
When milled	11.26	13.9	7.25	1.06	....	....	Do.
Stored 4 weeks	11.79	12.8	6.94	1.13	+ .45	+ .53	Do.
Stored 8 weeks	12.31	13.0	7.22	1.08	+1.25	+1.05	Do.
Stored 12 weeks	12.08	12.6	7.31	1.10	+1.48	+ .82	Do.
Stored 16 weeks	12.68	14.7	7.41	1.10	+1.50	+1.42	Do.
Stored 20 weeks	12.69	18.0	7.38	1.07	+2.09	+1.43	Do.
Stored 24 weeks	12.72	21.3	7.00	1.10	+2.12	+1.46	Do.
Stored 28 weeks	12.81	22.7	7.25	1.03	+2.30	+1.55	Do.
Meal stored at Savannah:							
Lot A, undried—							
When milled	19.20	16.0	7.38	.69	....	....	Do.
Stored 4 weeks	18.38	17.5	7.30	.73	− .65	− .82	No record.
Stored 8 weeks	17.67	20.0	7.60	.70	−1.83	−1.53	Do.
Stored 12 weeks	16.87	17.5	7.26	.60	−3.02	−2.33	Do.
Stored 16 weeks	16.40	18.5	7.61	.48	−3.52	−2.80	Do.
Stored 20 weeks	16.19	24.0	7.31	.36	−4.08	−3.01	Do.
Stored 24 weeks	15.70	25.0	7.50	.36	−4.52	−3.50	Musty.
Stored 28 weeks	14.95	22.0	6.79	.38	−5.29	−4.25	Do.
Lot B, extra low dried—							
When milled	17.73	17.6	7.50	.83	....	....	Good.
Stored 4 weeks	17.05	15.8	6.90	.88	− .46	− .68	No record.
Stored 8 weeks	16.70	22.0	6.90	.89	− .83	−1.03	Do.
Stored 12 weeks	16.66	24.0	7.18	.95	−1.46	−1.07	Do.
Stored 16 weeks	16.09	27.5	7.31	.84	−1.65	−1.64	Do.
Stored 20 weeks	15.75	33.7	7.59	.49	−2.40	−1.98	Do.
Stored 24 weeks	14.97	36.5	7.34	.53	−3.21	−2.76	Do.
Stored 28 weeks	14.50	33.2	7.41	.51	....	−3.23	Do.
Lot C, low dried—							
When milled	15.72	13.8	7.38	.75	....	....	Good.
Stored 4 weeks	15.31	12.0	7.31	.65	− .21	− .41	Do.
Stored 8 weeks	15.44	15.8	7.09	.83	− .46	− .28	Do.
Stored 12 weeks	15.49	16.5	6.82	.77	− .46	− .23	Do.
Stored 16 weeks	15.25	17.5	7.26	.79	− .46	− .47	Do.
Stored 20 weeks	15.02	22.5	7.59	.72	− .77	− .70	Do.
Stored 24 weeks	15.00	25.5	7.24	.72	−1.15	− .72	Do.
Stored 28 weeks	14.22	24.5	6.97	.87	−1.65	−1.50	Do.
Lot D, medium dried—							
When milled	13.78	13.3	7.28	1.05	....	....	Do.
Stored 4 weeks	13.98	10.3	7.35	1.13	+ .36	+ .20	Do.
Stored 8 weeks	14.16	15.8	7.09	1.07	+ .73	+ .38	Do.
Stored 12 weeks	14.13	15.5	6.82	1.12	+ .54	+ .35	Do.
Stored 16 weeks	14.09	17.0	7.26	1.09	+ .36	+ .31	Do.
Stored 20 weeks	14.30	23.0	7.15	1.12	+ .36	+ .52	Do.
Stored 24 weeks	14.07	25.5	7.23	1.05	− .08	+ .29	Do.
Stored 28 weeks	13.68	25.7	7.15	1.14	....	− .10	Do.

TABLE 12.—*Comparative analyses of whole-kernel, stone-ground corn meal and degerminated, bolted, roller-ground corn meal, etc.*—Continued.

Product.	Degerminated, bolted, roller-ground meal.						
	Moisture.	Acidity.	Protein (N×6.25).	Fat.	Change in weight.	Change in moisture.	Taste and appearance.
Meal stored at New Orleans—Con.							
Lot E, high dried—	*Per ct.*		*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	
When milled	12.91	13.0	7.41	0.92			Good.
Stored 4 weeks	12.16	9.5	7.00	.95	+0.23	−0.75	Do.
Stored 8 weeks	13.39	13.5	7.00	.98	+ .61	+ .48	Do.
Stored 12 weeks	13.35	14.5	7.09	1.00	+ .48	+ .44	Do.
Stored 16 weeks	13.45	15.0	7.00	1.03	+ .67	+ .54	Do.
Stored 20 weeks	13.58	19.0	7.15	1.09	+ .61	+ .67	Do.
Stored 24 weeks	13.32	20.5	7.24	1.00	+ .39	+ .41	Do.
Stored 28 weeks	13.27	22.5	7.10	1.04	+ .52	+ .36	Do.
Lot F, extra high dried—							
When milled	11.26	13.9	7.25	1.06			Do.
Stored 4 weeks	11.17	9.3	7.09	1.14	+ .73	− .09	Do.
Stored 8 weeks	11.49	12.0	7.45	1.15	+1.11	+ .23	Do.
Stored 12 weeks	12.30	13.0	7.09	1.13		+1.04	Do.
Stored 16 weeks	12.13	12.7	7.18	1.13	+1.11	+ .87	Do.
Stored 20 weeks	12.30	17.5	7.16	1.10	+1.48	+1.04	Do.
Stored 24 weeks	12.40	16.5	7.05	1.13	+1.42	+1.14	Do.
Stored 28 weeks	12.64	18.8	7.01	1.16	+1.67	+1.38	Do.

Special attention should be directed to the degerminated meal of lot A, which heated during the first four weeks and also became musty and lumpy. Notwithstanding the spoilage evident to the senses, this meal did not increase appreciably in acidity—in fact, at the end of 28 weeks it had less acidity than most of the dried meal. The pink color, as well as the mycological examination by Dr. C. Thom, showed that the flora of the sample was peculiar and evidently such as to produce spoilage without development of acidity.

Fat.—A marked diminution in the percentage of fat accompanied heating. This was evident in lots A, B, and C of the whole-kernel meal and lots A and B of the degerminated meal. This diminution was also noted in the experiments of the preceding year.

Protein.—The results show no significant change in total crude protein.

Taste and appearance.—Both the whole-kernel and the degerminated meal of lot A were hot, musty, and unfit for food four weeks after milling, and the whole-kernel meal of lot B was musty at the same period. The remainder of the whole-kernel meal became rancid in from 20 to 24 weeks. The degerminated meal of lots B and C was stale at the end of 20 weeks, but none of the lots with lower moisture content suffered appreciably in quality, even up to the end of the experiment.

CONCLUSIONS.

Whole-kernel meal prepared from corn of the quality of the crop of 1913, even when thoroughly dried, develops excessive acidity in so short a time as to demand immediate consumption. If meal of this type is preferred because of its greater nutritive value or more oily flavor, it should, as recommended by Commissioner Watson, be milled locally in small quantities and consumed within a short period.

In regard to keeping qualities, whole-kernel meal may be compared to cream in that it must be delivered and consumed without delay, while degerminated meal may be compared to butter, which within reasonable limits keeps until used.

STORAGE EXPERIMENTS WITH WHOLE-KERNEL AND DEGERMINATED MEAL, MILLED WITHOUT DRYING, APRIL 3, 1914.

The analyses of the meal as milled April 3, 1914, appear in Table 13, and of the meal after storage at New Orleans in Table 14. The percentages of moisture at the time of milling were 18.45 and 18.46, and of fat 3.34 and 0.79, respectively, in the whole-kernel and the degerminated meal.

TABLE 13.—*Composition of carload lots of whole-kernel, stone-ground corn meal and degerminated, bolted, roller-ground corn meal, as milled, without drying, Apr. 3, 1914, for use in storage experiments.*

Product.	Moisture.	Acidity.	Protein (N×6.25).	Fat.	Nitrogen-free extract.	Crude fiber.	Ash.
Meal as milled:	*Per ct.*		*Per cent.*	*P. ct.*	*Per cent.*	*Per ct.*	*P. ct.*
Whole-kernel stone-ground	18.45	30.0	8.94	3.34	66.23	1.78	1.26
Degerminated bolted roller-ground	18.46	17.9	6.97	.79	72.91	.46	.41
Moisture-free meal:							
Whole-kernel stone-ground		36.8	10.96	4.10	81.22	2.18	1.54
Degerminated bolted roller-ground		22.0	8.55	.97	89.42	.56	.50

TABLE 14.—*Comparative analyses of whole-kernel, stone-ground corn meal and degerminated, bolted, roller-ground corn meal, milled without drying, showing changes during storage.*

[Carload lots milled Apr. 17, 1914, and stored in 100-pound bags at New Orleans.]

Product.	Moisture.	Acidity.	Protein (N×6.25).	Fat.	Change in weight.	Change in moisture.	Taste and appearance.
Whole-kernel, stone-ground meal:	*Per ct.*		*Per cent.*	*Per ct.*	*Per ct.*	*Per cent.*	
When milled	18.46	30.0	8.94	3.34			Good.
Stored 2 weeks	15.41	82.7	8.85	2.79	−4.36	−3.04	Hot, musty, caked.
Stored 4 weeks	14.47	90.0	9.25	2.76	−5.72	−3.98	Musty, caked.
Stored 6 weeks	14.48	98.1	9.44	2.52	−5.73	−3.97	Rancid, caked.
Stored 8 weeks	14.55	98.7	9.38	2.78	−5.66	−3.90	Do.
Stored 12 weeks	13.85	94.8	9.38	2.71	−6.00	−4.60	Do.
Degerminated, bolted, roller-ground meal:							
When milled	18.46	17.9	6.97	.79			Good.
Stored 2 weeks	18.50	21.9	7.18	.73	− .30	+ .04	Not good.
Stored 4 weeks	16.06	20.3	7.31	.31	−3.81	−2.40	Musty, lumpy, pink.
Stored 6 weeks	15.53	21.0	7.53	.27	−4.67	−2.93	Do.
Stored 8 weeks	15.67	22.2	7.25	.34	−4.51	−2.79	Do.
Stored 12 weeks	15.19	22.1	6.75	.29	−4.56	−3.27	Do.

Neither kind of meal was fit for food at the end of two weeks' storage, the deterioration being evident from the taste and appearance, as well as in the case of the whole-kernel meal, from the acidity. As in lot A of the preceding experiment, the degerminated meal spoiled without developing excessive acidity.

SUMMARY.

1. The products of a white-corn mill may be arranged in the following order in regard to acidity, fat, fiber, and ash, beginning with the lowest percentage: Grits, meal, flour, feed, and germ. They may be arranged in the following order in regard to protein: Flour, meal, grits, feed, and germ. The percentage of nitrogen-free extract is not strikingly different in the grits and meal, but is lower in the feed and lowest in the germ.

2. Samples of meal taken from 41 mills located in 32 towns and 17 States are classified under four heads: (1) Whole-kernel, stone-ground meal; (2) bolted, undegerminated meal; (3) degerminated, bolted, roller-ground meal (''cream meal''); and (4) low-grade or ''standard'' meal.

3. Whole-kernel meal at the time of grinding is the same in composition as the corn except in regard to moisture, but soon develops a greater acidity.

4. Bolted, undegerminated meal contains less fiber than the corn, but no other general rule can be formulated owing to the variable conditions of manufacture.

5. Degerminated, bolted meal contains less protein, fat, fiber, and ash, but more nitrogen-free extract than the corn.

6. Low-grade (''standard'') meal contains sometimes more and sometimes less of each constituent than the corn.

7. Ton lots of degerminated, bolted meal, with a range in moisture content, were stored at Savannah and Chicago. The lot containing 16.86 per cent of moisture showed an excess of acidity in 12 weeks, a loss of fat in 16 weeks, and a musty taste in 20 weeks. The lot containing 15.04 per cent of moisture only slightly exceeded the limit for acidity (30) in 24 weeks, and did not suffer in taste or appearance, while those with 13.41 per cent or less kept well in all respects up to the end of the experiment (24 weeks).

8. Carload lots of degerminated, bolted meal, with 15.73 per cent of moisture, showed an excess of acidity at Savannah in 8 weeks and at Chicago in 12 weeks, but did not suffer appreciably in quality. Highly dried meal with 9.86 per cent of moisture after 24 weeks showed a maximum acidity of only 21.8.

9. Comparative tests with whole-kernel and degerminated, bolted meal, undried and dried to different degrees and stored at Savannah and New Orleans, showed the superior qualities of the latter. Even when dried to 10.79 per cent of moisture, the whole-kernel meal developed excessive acidity in 8 weeks and became rancid in 20

weeks, while with 15.71 per cent of moisture or higher, in addition to becoming acid, it sooner or later heated and caked. The loss in weight accompanying heating exceeded the loss of moisture.

Degerminated, bolted meal containing 13.78 per cent or less of moisture kept in all respects for 28 weeks, and that containing 15.72 per cent, although it became stale in 20 weeks, did not develop excessive acidity. The undried meal containing 19.20 per cent of moisture, although it heated within 4 weeks, unlike the whole-kernel meal, did not increase markedly in acidity.

10. Meal of the two kinds milled April, 1914, without drying and containing about 18.50 per cent of moisture, spoiled within 2 weeks at New Orleans. Only the whole-kernel meal developed an excess of acidity.

11. A study of all the results leads to the conclusion that degerminated, bolted meal containing not over 14 per cent of moisture and 1 per cent of fat, as determined by the method of the Association of Official Agricultural Chemists, properly stored, should keep for 6 months; with a moisture content of 15 per cent it should keep 3 months. Schindler's limit for moisture, namely 13½ per cent, obtained by drying in an open dish, corresponds to about 14½ per cent by the method of the Association of Official Agricultural Chemists.

12. Whole-kernel meal, like cream, should be produced locally and consumed soon after grinding; properly dried, degerminated meal, like butter, keeps well during transportation and long storage.

ADDITIONAL COPIES
OF THIS PUBLICATION MAY BE PROCURED FROM
THE SUPERINTENDENT OF DOCUMENTS
GOVERNMENT PRINTING OFFICE
WASHINGTON, D. C.
AT
5 CENTS PER COPY
▽